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14. ABSTRACT
The Combat Rations Network (CORANET) is a Defense Logistic Agency (DLA) sponsored manufacturing technology program to improve the quality, reduce the cost, and increase the productivity of operational rations while increasing DLA's surge capability in the area of military rations. This short term project, STP 2004,"Implement Ultrasonic Sealing of Preformed Pouches in Production", was funded from April 2002 through October 2004 to The Ohio State University (OSU). Project partners included the Edison Welding Institute (EWI), SOPAKCO Packaging, The Natick Soldier System Center, USDA/AMS, and Defense Supply Center Philadelphia (DSCP). Project team included Dr. Howard Zhang (OSU), Dr. Alex Savitski (EWI), Dr. Magdy Hefnawy (SOPAKCO), Mr. Denis Stewart (SOPAKCO), Mr. Peter Sherman (Natick), Mr. Richard Boyd (USDA) and Mr. Thomas Gordon (DSCP). Traditionally, the entrees included in Meal, Ready-to-Eat (MRE) are either pumped or placed into multi-laminate foil pouches that are then hermetically sealed and exposed to heating (retorting) to extend the shelf life and prevent contamination during storage and

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Implementation: Ultrasonic Sealing of Preformed Pouches in Production

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Abstract

The Combat Rations Network (CORANET) is a Defense Logistic Agency (DLA) sponsored manufacturing technology program to improve the quality, reduce the cost, and increase the productivity of operational rations while increasing DLA's surge capability in the area of military rations. This short term project, STP 2004,"Implement Ultrasonic Sealing of Preformed Pouches in Production", was funded from April 2002 through October 2004 to The Ohio State University (OSU). Project partners included the Edison Welding Institute (EWI), SOPAKCO Packaging, The Natick Soldier System Center, USDA/AMS, and Defense Supply Center Philadelphia (DSCP). Project team included Dr. Howard Zhang (OSU), Dr. Alex Savitski (EWI), Dr. Magdy Hefnawy (SOPAKCO), Mr. Denis Stewart (SOPAKCO), Mr. Peter Sherman (Natick), Mr. Richard Boyd (USDA) and Mr. Thomas Gordon (DSCP).

Traditionally, the entrees included in Meal, Ready-to-Eat (MRE) are either pumped or placed into multi-laminate foil pouches that are then hermetically sealed and exposed to heating (retorting) to extend the shelf life and prevent contamination during storage and handling. Preformed pouches in MRE's have traditionally been filled and sealed by heated tools in a process that often results in splashing of the food product and contamination of the sealed area. A steady reject-rate range from 1.5 to 4.5% with an average of 3% cross the industry is related to seal defects. The need was identified by the industry to improve seal quality.

Ultrasonic sealing technology appeared to hold promise for solving this problem in MRE production. The objective was to demonstrate the proof of concept of ultrasonic sealing of MRE pouches in production by retrofitting a preformed pouch package machine. Ultrasonic sealing delivers heat to the seal interface by mechanical vibration. Earlier research showed that the internal heat generation combined with mechanical vibration makes this seal technique tolerable to seal area contaminations.

OSU worked with EWI and SOPAKCO to retrofit a Bartelt single lane preformed pouch packaging machine. The 20-kHz 2-kW ultrasonic welding system included a 9 inch balanced amplitude and smooth face horn, a stainless steel female-knurled anvil, and pneumatic control system. Installation was first attempted following the cooling bar of the Bartelt. This did not provide enough cooling time and resulted in wrinkles in the seal area. The ultrasonic seal station was then reinstalled to replace the heat-seal unit and the operation incorporated the cooling bar. Optimization was conducted in energy mode with appearance and peel tests as seal quality indicators. Production was conducted in 8-h shifts at 32 pouches per minute. Products were retorted at 250F to achieve commercial sterility. The quality of the MRE pouches were evaluated by visual inspection, burst tests and peel strength tests.

After three iterations of optimization, the produced pouches passed manufacturer evaluations, passed the USDA on-site evaluation and were accepted by DSCP. Ultrasonic sealing resulted in significant decrease of number of rejects due to seal area contamination from 5.6% to 1.9%. The producer also found that throughput could be increased from 32 pouches per minute to 45 pouches per minute, compared to conventional heat sealing. A number of open-seals that failed the inspection are likely due to the warm-up phase of the ultrasonic seal operation and can be fixed by improved design of ultrasonic-seal unit. This is the first implementation of ultrasonic sealing of aluminum-foil laminated package materials in MRE production.

1. Results and Accomplishments

1.1. Introduction and Background

In the retort pouch making industry, most pouches are pre-formed and are filled with product with the closure (fourth) seal made after filling. This sachet type of pouches are prone to seal area contamination when a product has a liquid phase that is highly viscous, such as a soup product, a sauce product, or even a beverage type of product. In the vertical form-fill-and-seal operation of liquid food, the sealing process is designed to seal through the product to eliminate the headspace. In some of the pouch filling operations, steam is injected to the pouch after filling to evacuate air from the pouch headspace. The condensed steam, as water droplets, can also cause seal defects in current heat-seal units.

Ultrasonic sealing is a good candidate for making the closure seal on the preformed pouch, through the product contamination, after filling and steam injection. A major food package company already utilizes ultrasonic sealing to make the closure seal of a vertical-form-fill-and-seal process of liquid beverage in a laminate-paper brick style package. Ultrasonic sealing or joining is a technology that utilizes ultrasound as a means of energy delivery to the interface of two pieces of plastics held together. The sound frequencies are in the range of 20 kHz to 40 kHz. This method of energy delivery has the advantage of higher temperature at the joining interface and lower temperature outside. This is in contrast to traditional heat-seal, where heat is conducted from the heated tool, through the package material to the joining interface. Heat-seal is prone to seal area contamination where contaminants limits the seal temperature, as heat transfer is limited by the thermal conduction of packaging, to that below the melting point of joining plastic materials, thus resulting in seal area defects. The hammering effect of ultrasound further helps expel seal-area contaminants. Ultrasonic sealing is known to enhance seal integrity of plastic materials.

The results of earlier projects (STP1013 and STP1013A) have demonstrated that ultrasonic sealing is effective for bonding and sealing two layers of laminated film that is typically used in preformed MRE pouches. The initial study (STP1013) was conducted with participation of five leading ultrasonic equipment manufacturers, Branson Ultrasonics, Dukane Ultrasonics, Forward Technology, Sonics and Materials, and Sonobond. We identified the plunge welding method and Dukane Ultrasonic's approach as most promising option for sealing of MRE pouches. Based on technical requirements developed by Edison Welding Institute (EWI), a bench top prototype system was designed and built by Dukane Ultrasonics. The system was successfully tested and used to evaluate a variety of conditions, and the results are very promising. Specifically, ultrasonic sealing seems to be very tolerable to seal area contaminants, thus avoiding defects that are frequently found in seals as they are currently sealed. Prototype tests of preformed MRE pouches have been successful. Ultrasonic sealed, preformed tri-laminate, pouches met or exceeded package-integrity requirements even with significant seal-area contamination (STP1013A Project Report). Ultrasonic sealing technology is ready for implementation in actual production of preformed MRE pouches.

Economic analysis in STP1013A shows significant benefit of implementing ultrasonic sealing to a pre-formed pouch line. The estimated Return-of-Investment (ROI) is less than one year. An economic model spreadsheet provided industry first hand estimates of cost savings and improvement in product quality. Feasibility of production implementation was justified from the engineering and cost perspectives. It would be the easiest to implement in an in-line pouch package line, where the pouches travel in-line with the sealing mechanism (such as a Bartelt).

Mechanical installation is simply to replace existing heat-seal station(s) with that of ultrasonic. A transverse line (such as a Mitsubishii) may also be retrofitted, where an additional mechanism may be required to feed pouches through the ultrasonic sealing station. Cost analysis estimates the return on investment as less than one year. Significant improvement to seal area defects is expected when ultrasonic sealing is implemented.

Building on the successful experience of earlier projects, The Ohio State University (OSU) and EWI team proposed to retrofit a preformed-pouch line as a technology demonstration. The US Army Natick Soldier Center, DSCP and USDA assisted the objective evaluations of production results.

SOPAKCO and Unaka Company are partners and provided a Bartelt line in their facility for this proposed implementation. SOPAKCO also provided products, materials and production labor to assist the optimization and evaluation studies. Demonstration production runs were videotaped for the CORANET Program.

1.2. Objectives

The objective of this project is to scale up and test the ultrasonic sealing technology in an actual production environment by retrofitting sealing capability and applying it to existing production sealing equipment found in industry. The target line speed for sealing pouches shall be from 40 to 60 pouches per minute, with significantly fewer quality defects.

1.3. Results and Conclusions

The majority of technical results and supporting details are included in Appendix 4.3, EWI Subcontract Final Report. This section provides a summary of the results reported in EWI's report and presents results from the production evaluations beyond October 2004.

1.3.1. Impact on inspection

No major change was imposed to inspection criteria and procedure by ultrasonic sealing, except recommendation to require 1/8" minimum seal width compared to a 1/16" minimum seal width for heat seal of MRE pouches. This was considered prudent until data was collected to support the 1/16" width. As for any new process, the project team recommended increased sample sizes for the manufacturer's and the USDA's inspections. These sample sizes were gradually relaxed to the levels of heat sealed products after a number of production runs without reject. The 1/8" minimum seal width was recommended based on the seal pattern of ultrasonically sealed pouches.

1.3.2. Production line speed and throughput

Ultrasonic sealing may result in increased line speed. The Bartelt operated at 45 pouches per minute with US sealing compared to 32 pouches per minute with original heat sealing. Production experiments were conducted to increase the line speed from 32 to 35, 40, 45, and 50 pouches per minutes. The ultrasonic sealing unit ran normally at 50 pouches per minute. The Bartelt machine, however, was not able to synchronize the grippers at the increased rate of 50 pouches per minute. Therefore, 45 pouches per minute was a limitation of the Bartelt.

Theoretically, the ultrasonic sealing unit requires 0.9 seconds dwell time, which translates to approximately 60 pouches per minutes allowing time for mechanical movements. Compared to conventional heat sealing, ultrasonic sealing has the potential to increase line speed by approximately 50%. This increase in line speed can translate into a 50% increase in production throughput.

1.3.3. Tolerance to seal area contamination

Ultrasonic sealing is tolerable to seal area contamination as tested under laboratory and production conditions. Under both conditions, ultrasonic sealing provided seals that have seal strength, peel strength and resistance to internal pressures characteristics, similar to those of uncontaminated pouches and met the inspection requirements. This is observed from Tables 1 and 2 where none of the failed lots were rejected due to internal pressure failures.

1.3.4. Defect reduction

Ultrasonic sealing may reduce seal defects. Table 2 presents a summary of the USDA inspections. The number of lots failing for seal defects gradually reduced from 7.4% to 3.1% which is similar to the 2.6% failing rate by the SOPAKCO. This trend indicates that the operators were learning about the system and made progress in reduction of rejects. The number of lots failing for internal pressure was maintained at 0% throughout the test for ultrasonically sealed pouches.

Table 1 presents detailed information about each lot of product and the reason why a specific lot failed the inspection. A total of 11 lots failed the first USDA inspection over the 121 lots offered. For the 11 failed lots, 1 lot failed for residual gas and one lot failed for cut (hole) which are not seal related failures. The remainder of 9 lots all failed due to open seal. And the frequency of this failure decreased along with time. For the first three months of production, lot 4161A through lot 4244A, 6 of the 27 lots failed due to open seal resulting in 22% failing rate. This is a period where training and learning took place. For the second three months of the production period, lot 4245A through lot 4343A, only 1 of the 53 lots failed due to open seal, resulting in 1.9% reject rate. During the last two months of production, lot 4344A through lot 5046A, 2 of the 31 lots (6.4%) failed due to open seal.

The project team believes that open seals may be caused by the need to warm up the ultrasonic horn (page 47 of EWI report). Each time the seal operation is interrupted, the operator is required to run two minutes worth of blank pouches to re-establish the thermal dynamic equilibrium as the length of the horn is a function of the horn temperature. Occasionally, the operator may ignore this operating procedure to reduce losses in pouch material. This might be the reason for the open seals.

1.3.5. Tolerance to extreme cold temperature

Inclined slide tests were performed on the pouch samples after each of the earliest production runs during the study. The tests were conducted in accordance with the Military Performance Specification, MIL-PRF-44073 "Packaging of Food in Flexible Pouches" to assure that all requirements of the specification were considered to fully demonstrate the viability of the ultrasonic seals. Test pouches in paperboard cartons were conditioned to -20˚F for 48 hours prior to testing. The test protocol is to slide the pouch down an incline from a predetermined drop height, based on the weight of the object. After testing, fractures were seen in the ultrasonic closure in 17 of 36 samples. The fractures tended to occur along the grid line of the patterned seal. These types of fractures have not been experienced in heat seal closures tested when under the same conditions.

The original anvil surface was machined to provide a knurled seal texture produced from creating a standard "T" pattern consisting of straight up and down vertical lines crossed by perpendicularly spaced horizontal lines. It was postulated by Edison Welding Institute (EWI) that a cross-hatch or "X" pattern may provide a stronger resistance to the forces generated in the slide test. Accordingly, an anvil surface facing with a cross-hatch pattern was designed and fabricated and sample pouches were sealed on the "X" pattern anvil for evaluation. Testing was conducted on the pouches exhibiting the cross-hatch pattern. It was determined that the EWI theory was correct, test failures were greatly reduced to 1/24 (4.2%) versus the previous result of 17/36 (47%) and the cross-hatch pattern was adopted for the remainder of the ultrasonic sealing study. (Please note: When testing foil laminated pouches filled with food materials conditioned to this temperature extreme a failure rate below 10% is a highly acceptable result).

1.3.6. Development needs

There is the potential to achieve near-zero defects due to seal failures using ultrasonic sealing. Improvements are needed to ensure the operating condition. There is a need to improve start-up procedures with advanced controls to eliminate the use of empty pouches to warm-up the US seal horn and thus to eliminate open seals. Two approaches are recommended for future implementation: A) installing a temperature controlled heating element to the horn to maintain its operating temperature in the range of 140 to 150F; and B) using a programmable ultrasonic sealing unit that delivers ultrasonic energy as a function of the horn temperature. For the SOPAKCO installed system, the first approach may improve the current operation. For new installations, we recommend the second approach. The new models of Dukane ultrasonic units come with the option of start-up programming. The user will need to program the energy level along with a starting time. A step down energy curve may be optimized to eliminate the need for running blank pouches.

1.4. Recommendations

Ultrasonic sealing is recommended for sealing of preformed aluminum laminate MRE pouches for its tolerance to seal area contamination and higher speed of energy delivery. Ultrasonic sealing may help reduce seal defects and increase line speed. Future implementations are recommended to optimize the operation and to realize the benefits of reduced rejects and increased line speed. Design of the ultrasonic sealing system should be improved to eliminate the need for warming-up the horn after each stoppage. Future research and development work is recommended to explore the application of ultrasonic sealing in horizontal form-fill-seal operations, for both pouches and polymeric trays.

Table 1 Detailed inspection results – from USDA

Results from 1st USDA Inspection of Ultrasonically Sealed Lots Produced at SOPAKCO under CORANET*							
Lots offered to USDA	**Date Offered**	**Product**	**Lot #**	**# Cased**	**Pass 1st USDA Inspection**	**Fail 1st USDA Inspection**	**Reason Rejected by USDA**
1	06/14/04	Cajun Rice and Beans	4161A	2,304		1	Open Seal
1	06/15/04	Chicken Tetrazzini	4162A	3,960		1	Open Seal
1	06/17/04	Raspberry Applesauce	4163A	4,525	1		
1	06/17/04	Mexican Rice	4166A	6,784	1		
1	06/19/04	Chicken Noodles	4167A	8,718		1	Open Seal & Foldover Wrinkle
1	06/21/04	Raspberry Applesauce	4168A	1,490	1		
1	07/24/04	Mexican Rice	4201A	8,327	1		
1	07/27/04	Raspberry Applsauce	4202A	5,581	1		
1	08/02/04	Yellow Rice Pilaf	4203A	8,827		1	Open Seal
1	07/28/04	Minestrone Stew	4204A	6,840	1		
1		Beef Teriyaki	4205A	9,537	1		
1	08/02/04	Cheese Tortellini	4208A	9,411		1	Open Seal & Foldover Wrinkle
1	07/31/04	Spaghetti w/ Meat sauce	4209A	7,122	1		
1	08/03/04	Western Beans	4210A	11,131	1		
1	08/06/04	Chicken in Salsa	4211A	9,856	1		

1	08/05/04	Mexican Macaroni & Cheese	4212A	13,109	1		
1	08/06/04	Applesauce (Carbo Enhanced)	4213A	10,296	1		
1	08/20/04	Mexican Rice	4222A	2,127	1		
1	08/23/04	Cheese Tortellini	4224A	4,570	1		
1	08/19/00	Pasta w/ Vegetables	4226A	6,794	1		
1	08/22/04	Raspberry Applesauce	4227A	2,870	1		
1	08/30/04	Mexican Rice	4229A	10,800	1		
1	09/03/04	Yellow Rice Pilaf	4230A	12,425	1		
1	08/23/04	Pasta w/ Vegetables	4231A	7,071		1	Open Seal
1		Clam Chowder	4241A	8,364	1		
1		Raspberry Applesauce	4241A	10,717	1		
1	09/07/04	Yellow Rice Pilaf	4244A	9,349	1		
1	09/14/04	Minestrone Stew	4245A	4,868	1		
1	09/14/04	Mexican Rice	4246A	9,494	1		
1	09/15/04	Raspberry Applesauce	4247A	9,817		1	Cut (hole)
1	09/14/04	Minestrone Stew	4252A	539	1		
1	09/15/04	Minestrone Stew	4253A	4,968	1		
1	09/29/04	Mexican Macaroni & Cheese	4257A	9,247	1		
1	09/27/04	Raspberry Applesauce	4259A	9,440	1		
1	09/27/04	Raspberry Applesauce	4264A	9,652	1		
1	09/28/04	Applesauce (Carbo Enhanced)	4265A	7,919	1		
1	09/28/04	Applesauce (Carbo Enhanced)	4266A	10,829	1		

1	09/28/04	Applesauce (Carbo Enhanced)	4267A	9,936	1		
1	10/01/04	Refried Beans	4268A	7,946	1		
1	10/08/04	Chicken Noodles	4278A	8,792	1		
1	1025/04	Mashed Potatoes	4279A	9,544	1		
1	10/12/04	Chicken Tetrazzini	4280A	10,469	1		
1	10/12/04	Mexican Rice	4281A	11,677	1		
1	10/12/04	Beef Ravioli	4282A	10,656	1		
1	10/14/04	Yellow Rice Pilaf	4283A	4,049	1		
1	10/15/04	Mashed Potatoes	4285A	9,932	1		
1	10/18/04	Cheese Tortellini	4286A	7,281	1		
1	10/15/04	Refried Beans	4287A	11,718	1		
1	10/19/04	Western Beans	4288A	8,217	1		
1	10/19/04	Western Beans	4289A	12,125	1		
1	10/21/04	Beef Ravioli	4290A	6,174	1		
1	10/22/04	Pasta w/ Vegetables	4292A	7,367	1		
1	11/01/04	Minestrone Stew	4294A	10,662		1	Open Seal and Hole/Cut
1	10/27/04	Mexican Rice	4295A	9,520	1		
1	10/29/04	Chicken Tetrazzini	4297A	6,029	1		
1	10/29/04	Pasta w/ Vegetables	4299A	11,104	1		
1	10/30/04	Chili Macaroni	4300A	10,294	1		
1	10/30/04	Applesauce (Carbo Enhanced)	4301A	11,661	1		
1	11/02/04	Jambalaya	4302A	8,896	1		

1	11/04/04	Spaghetti w/ Meat sauce	4303A	12,312	1		
1	11/04/04	Mashed Potatoes	4304A	8,934	1		
1	11/17/04	Beef Stew	4306A	13,016	1		
1	11/10/04	Mashed Potatoes	4308A	5,922	1		
1	11/12/04	Yellow Rice Pilaf	4310A	10,707	1		
1	11/15/04	Mexican Rice	4313A	10,935	1		
1	11/15/04	Clam Chowder	4314A	12,046	1		
1	11/19/04	Beef Enchilada	4316A	17,384	1		
1	11/20/04	Beef Stew	4321A	8,948	1		
1	11/24/04	Yellow Rice Pilaf	4323A	8,794	1		
1	12/01/04	Mexican Rice	4324A	10,050	1		
1	12/02/04	Chicken Tetrazzini	4328A	7,456	1		
1	12/02/04	Cajun Rice and Beans	4329A	12,447	1		
1	12/07/04	Mexican Macaroni & Cheese	4334A	10,125	1		
1	12/07/04	Cajun Rice and Beans	4335A	9,581	1		
1	12/08/04	Beef Ravioli	4336A	5,758		1	Residual Gas
1	12/08/04	Applesauce (Carbo Enhanced)	4337A	5,090	1		
1	12/10/04	Yellow Rice Pilaf	4338A	10,008	1		
1	12/13/04	Raspberry Applesauce	4341A	10,717	1		
1	12/14/04	Cheese Tortellini	4342A	9,933	1		
1	12/15/04	Clam Chowder	4343A	12,240	1		
1	01/03/05	Chili Macaroni	4344A	8,388	1		

1	12/17/04	Raspberry Applesauce	4345A	12,329	1		
1	01/06/05	Minestrone Stew	4348A	5,709	1		
1	12/21/04	Refried Beans	4349A	10,892	1		
1	01/03/05	Chicken w/ Salsa	4350A	7,223	1		
1	01/03/05	Beef Ravioli	4351A	3,876	1		
1	01/05/05	Chicken Noodles	4352A	5,544	1		
1	12/20/04	Cheese Tortellini	4355A	10,008	1		
1	01/07/05	Cheese Tortellini	4355A	10,008	1		
1	01/05/05	Beef Stew	4356A	11,893	1		
1	01/10/05	Beef Teriyaki	4357A	9,648	1		
1	01/10/05	Raspberry Applesauce	5003A	4,084	1		
1	01/12/05	Chili Macaroni	5004A	10,194	1		
1	01/12/05	Chicken Noodles	5005A	10,609	1		
1	01/14/05	Clam Chowder	5006A	9,504	1		
1	01/14/05	Chicken Tetrazzini	5007A	10,430	1		
1	01/18/05	Yellow Rice Pilaf	5010A	11,550	1		
1	01/18/05	Raspberry Applesauce	5011A	10,307	1		
1	01/20/05	Minestrone Stew	5012A	9,974	1		
1	02/01/05	Cheese Tortellini	5013A	8,768		1	Open Seal
1	01/21/05	Beef Ravioli	5014A	9,929	1		
1	01/24/05	Pasta w/ Vegetables	5018A	11,155	1		
1	01/26/05	Clam Chowder	5019A	11,736	1		

1	01/26/05	Chicken w/ Salsa	5020A	8,712	1		
1	01/26/05	Spaghetti w/ Meat sauce	5021A	11,448	1		
1	01/31/05	Mexican Rice	5024A	11,795	1		
1	02/01/05	Chicken Thai	5025A	8,280	1		
1	02/01/05	Beef Ravioli	5026A	11,149	1		
1	02/04/05	Jambalaya	5027A	10,344	1		
1		Applesauce (Carbo Enhanced)	5028A-A	2,222	1		
1	02/22/05	Applesauce (Carbo Enhanced)	5028A	5,710	1		
1	02/08/05	Clam Chowder	5031A	12,182	1		
1	02/07/05	Mexican Rice	5032A	11,923	1		
1	02/09/05	Beef Teriyaki	5033A	10,634	1		
1	02/21/05	Applesauce (Carbo Enhanced)	5035A	3,120	1		
1	02/15/05	Refried Beans	5038A	10,797		1	Open Seal
1	02/15/05	Raspberry Applesauce	5039A	10,667	1		
1	02/22/05	Beef Ravioli	5041A	6,616	1		
1	02/18/05	Pasta w/ Vegetables	5042A	9,829	1		
1	02/18/05	Mashed Potatoes	5045A	11,944	1		
1	02/22/05	Clam Chowder	5046A	12,600	1		

* Data obtained from SOPAKCO and USDA/AMS sources: "Date Offered" and "# Cased" provided by SOPAKCO. 5/20/05

Table 2. COMPARISON OF ULTRASONICALLY SEALED LOTS FROM SOPAKCO WITH OTHER MRE RETORT POUCH PRODUCTION
All Results Are from 1st USDA/AMS Inspection

		Number of Lots	Number of Lots Failing for Seal Defects	Percentage of Lots Failing for Seal Defects	Number of Lots Failing for Internal Pressure	Percentage of Lots Failing for Internal Pressure	Total Number of Lots Failing for Seal Defects and/or Internal Pressure	Percent of Lots Failing for Seal Defects and/or Internal Pressure
Ultrasonically Sealed Lots under CORANET Project	All lots since (and including) lot 4161	121	9	7.4%	0	0	9	7.4%
	All lots after first 6 lots	115	6	5.2%	0	0	6	5.2%
	All lots after first 17 lots	104	4	3.8%	0	0	4	3.8%
	All lots after first 24 lots	97	3	3.1%	0	0	3	3.1%
Lots Produced at SOPAKCO from 1/1/04 to 3/31/05, (does not include ultrasonically sealed lots)	Vertical Fill Lots	821	21	2.6%	1	0.1%	22	2.7%
	HFFS Lots	440	16	3.6%	5	1.1%	21	4.8%
Industry Wide, Vertical Fill and HFFS (does not include ultrasonically sealed lots)	MRE 24*	3020	37	1.2%	9	0.3%	46	1.5%
	MRE 23	2299	38	1.7%	2	0.1%	40	1.7%
	MRE 22	5902	245	4.2%	20	0.3%	265	4.5%
	MRE 21	2378	48	2.0%	21	0.9%	69	2.9%
Industry Wide Vertical Fill (Pre HFFS)	MRE 17	1919						2.6%
	MRE 16	1294						2.9%
	MRE 15	1542						3.1%
	MRE 14	1297						2.2%

*MRE 24 as reported in USDA/AMS Operational Rations Database through 1/13/05;
HFFS = Horizontal Form Fill Seal Pouches; Vertical Fill = Preformed Pouches

5/20/05

2. Program Management

This short term project was a team project. As principal investigator, Dr. Howard Zhang at OSU managed and coordinated this project. As co-investigator, Dr. Alex Savitski of EWI led the design, installation and optimization of the ultrasonic sealing unit. EWI procured the ultrasonic sealing unit from Dukane. EWI sub-contracted the design and fabrication of the brackets and pneumatic parts and installation to the Bartelt to Chase Machinery. Dr. Magdy Hefnawy together with Dennis Stewart coordinated the installation, production and evaluation activities in SOPAKCO. Mr. Peter Sherman and Mr. Richard Boyd evaluated sealed samples, proposed inspection schedule and served as quality control officials to this project. Mr. Thomas Gordon represented the buyer, evaluated products and actively participated in this project.

During this project, the Operation Iraqi Freedom commenced. SOPAKCO had to increase its production rate. The Bartelt machine was not available for installation. The decision to install the ultrasonic unit after the cooling bar enabled SOPAKCO to turn off ultrasonic sealing and go back to heat sealing operation during the optimization phase. The inherent problem of not having enough cooling time resulted in wrinkles. The uneven gap between the horn and the anvil resulted in localized eruptions in the seal area. The project team worked together and identified solutions to these problems and resolved the issues. Addition of air cooling reduced wrinkles. The OSU team developed a parallel alignment tool that eliminated the eruptions.

After the reduction in production, SOPAKCO decided to accommodate the original design of installing the ultrasonic sealing unit to replace the heat sealing unit. This project was extended October 2004 with additional funds to complete this task. After the re-installation of the ultrasonic unit and incorporating the cooling bar, SOPAKCO was able to produce much more consistent pouches. The appearance of the seal area, however, changed with an over-lapping texture of the cooling bar. The project team thoroughly evaluated the products and concluded that the use of the cooling bar had positively impacted the quality of the seal. It also shortened the dwell time of ultrasonic sealing and provided high potential line speed. Phase III production evaluation was initiated.

Progress and results of this project were presented to CORANET partners during CORANET workshops. Several IPRs took place to ensure completion of each project phase and planning for entering the next phase.

This CORANET project demonstrated the feasibility of implementing a manufacturing technology directly into production of MRE. The project team believes that this approach is a short cut to the traditional development cycle of research, development, demonstration in the demo facility, and waiting for industrial partner to pick up. We believe that each manufacturing technology should have at least one industrial partner who is committed to the implementation of the technology.

The dedication and leadership of all team members are major reasons for the successful completion of this project. Together, we make good pouches!

3. Project Activities

Technical and cost proposals were submitted to DSCP on April 18, 2002. Contract was awarded late in April, 2002 with an effective period of May 15, 2002 through December 14, 2003. This completion date was extended to September 30, 2004.

A project kick-off meeting was conducted during the R&DA on May 28th, 4:00-6:00 PM with the following agenda:

Introduction
Overview of tasks and deliverables
Project management and POC
Project accounting and procedures
EWI tasks and responsibilities
SOPAKCO tasks and responsibilities
Natick tasks and responsibilities
USDA tasks and responsibilities
DLA coordination
Schedule of major events and in-process-reviews
Hurdles and areas of caution
Recap and adjourn

3.1. Phase I

3.1.1. Planning

A site visit and project planning meeting took place in SOPAKCO on July 23rd and 24th, Bennetsville, SC.
This meeting covered the following agenda:
July 23

Introductions and agenda review
Packaging process review on Bartelt and other types of MRE machines
Discussion of technical and economical feasibility of retrofitting different types of packaging lines with ultrasonic sealing components

July 24

Discussion of plans to retrofit the Bartelt machine:
Development of specifications for the retrofitting:
- MRE manufacturer's requirements
- Identifying ultrasonic components
- Requirements for the system integration

Development of a working schedule

Participated in this meeting:

JSG
- Russell Eggers, DLA
- Peter Sherman, SBCCOM
- Carol Norton, SBCCOM

OSU/EWI
- Howard Zhang, OSU
- Alex Savitski, EWI

SOPAKCO
- Magdy Helfnawy, Unaka

Lisa Prince, SOPAKCO
Equipment manufacturers
Alan Baxter, Dukane
James “Les” Kimley, Dukane
Julian Rokicki, Chase Machine

3.1.2. Evaluations

The bench top ultrasonic sealing machine was set up, in August 2002, and tuned for the optimization study with quad laminate pouches. Blank pouches are sealed with acceptable seal strength. The optimization study with quad laminate pouches was completed in October 2002. Blank pouches from all four supplies are sealed with ultrasonic satisfactorily with peal test and microscopic inspection.

In November 2002, product refilling, ultrasonic sealing and retorting were performed. More than 300 pouches were processed, re-sleeved and packaged. Seventy two pouches were shipped to Natick and 72 were shipped to USDA. A limited number of pouches were shipped to DSCP. A limited number of pouches were shipped to SOPAKCO, amongst which 10 pouches had intentional seal area contamination. This contamination experiment was conducted at the request of SOPAKCO as a confirmative test.

The first in process review (IPR #1) took place as part of the CORANET II.5 Workshop in Knoxville, TN on December 11, 2002. Participants included:

Dr. Howard Zhang, PI, OSU,
Dr. Alexander Savitski, Co-PI, EWI
Mr. Peter Sherman, Co-PI, Natick
Mr. Tom Gordon, Co-PI, DSCP
Mr. Richard Boyd, Co-PI, USDA
Mr. Russell Eggers, Contract Manager, DLA
Dr. Magdy Hefnawy, Partner, SOPAKCO
Ms. Lisa Prince, Partner, SOPAKCO
Mr. Jesse Burns, DSCP

Mr. Eggers concluded that the tasks of Phase I have been conducted and the results obtained were successful and as expected. While Peter Sherman of Natick will continue to test a few samples, this project was ready to proceed to Phase II.

Passed IPR#1 and project was ready to move into Phase II to procure and implement ultrasonic sealing equipment to a Bartelt machine.

A number of intentionally contaminated pouches were produced, based on SOPAKCO request. Pouches were tested in EWI and provided to SOPAKCO. All of these pouches had 100% of seal area cross-section contaminated with food product (Minestrone). The length of the contaminated area varied from 1/4- to 11/4- inch. Seal strength of contaminated area is higher than 12 lb/in.

Project Team has reviewed four types of MRE pouch machines and evaluated technical feasibility of retrofitting them with ultrasonic sealing equipment components. Cost estimates were requested and obtained from the system integrator for retrofitting all existing pouch lines.

All of the machines that were inspected at SOPAKCO can be retrofitted with Ultrasonic Welding technology. No technical obstacles preventing future modifications were discovered. It was confirmed by the Klockner Bartelt, that “US sealers could readily be designed into a "trade-out" for the currently quoted pre-heat and heat sealers. If for some reason it was felt necessary to go back to heat sealing, the heat sealing assemblies could be retro-fitted.”

3.2. Phase II

3.2.1. Design of ultrasonic sealing equipment

In January 2003, sub-contracts were issued to Chase and Dukane for design, construction and installation of ultrasonic sub-system. Representatives from Chase Machine and Engineering, and Dukane Ultrasonics visited SOPAKCO and came up with mechanical design. Ultrasonic sub-system was designed.

3.2.2. Fabrication of components

In February 2003, Chase Machine and Engineering completed manufacturing all the components of the integration module, including custom-designed anvil with fine female knurl on it. The block was fabricated by Chase, and then it was sent to Dukane that put the knurl on the block face. EWI had provided technical consultations for the knurl design and coordinated Dukane’s and Chase’s activities to deliver it in time. Ultrasonic components had been sent to Chase for the module assembly.

In March 2003, the integration module had been assembled and tested. The system run off had been conducted by EWI, Chase M&E and Dukane Ultrasonics. This included:

- Building of a temporary pouch-holding fixture for sealing process modeling
- 3-D horn and anvil precision alignment
- Circuit and controllers testing
- Ultrasonic sealing process testing
- One of two horns’ surface modification, based on initial test results, and preliminary process settings optimization

Based on the tests, this system was concluded to be ready for shipping and installation at SOPAKCO production site.

Based on Natick evaluations, stress-cracks developed in the seal area when ultrasonic sealed pouches were subjected to extreme cold weather condition (not currently in specification). An additional task was added to the STP 2004 to optimize the pattern and size of the knurl to minimize stress-concentration when pouches are subject to impact under extreme cold weather conditions.

3.2.3. Installation

A conference call took place on Thursday April 17, 2003 to develop the installation plan. The following agenda was discussed and action items developed:

1. Pre-installation phase, SOPAKCO
2. Final Installation, Chase Machine with help from SOPAKCO, on April 21
3. Set up, Optimization and Training

EWI, Chase and Dukane with help from SOPAKCO on April 22
4. Initial evaluation of performance, EWI and SOPAKCO, April 22 to April 24
Pre-installation, final installation, setup and initial evaluation were performed as scheduled.

3.2.4. Evaluations

The second in process review (IPR#2) took place on May 14 and 15th, 2003 in Bennettsville, SC. The following participated this IPR:

Dr. Howard Zhang, PI, OSU
Dr. Alexander Savitski, Co-PI, EWI
Mr. Peter Sherman, Co-PI, Natick
Mr. Tom Gordon, Co-PI, DSCP
Mr. Richard Boyd, Co-PI, USDA
Dr. Magdy Hefnawy, Partner, SOPAKCO
Mr. Lonnie Thompson, Sopakco
Mr. Jesse Burns, DSCP
Mr. Larry Parham, Partner, Sopakco
Mr. Dennis Stewart, Partner, Sopakco
Mr. Bob Bishop, Partner, Sopakco

A few issues were identified and improvements suggested. This IPR served as Part 1 of IPR#2.

On 6/17/03 SOPAKCO team conducted a trial run using the Ultrasonic seal on the Bartelt machine line-8 at Bennettsville plant. The purpose of the trial was to assess the feasibility of incorporating an air cooling line, immediately after the US sealer, to reduce pouch temperature in the attempt to eliminate the wrinkles defect that was observed during the installation/optimization production run.

Temperature of the pouch's sealing area was taken using hand held I.R. thermometer. The Bartelt Machine operated at a speed of the 32 pouch/minute and the temperature of the sealing area on the pouch was taken, at the empty station immediately following the sealer and before clamps release, at the following conditions:

Horne side: pouches with product, without product and filled pouches without air-cooling.
Anvil side: filled pouches with and without air-cooling

Pouches were inspected, retorted and re-inspected after retorts for defects.

Four cases (72 pouches) were pulled from the trial run and a case was sent to the OSU/ EWI; USDA; and Natick for evaluation.

OSU developed a horizontal alignment tool that reads the forces on both ends of the gap between the horn and anvil. A difference in the force readings would indicate non-parallel in the alignment. This tool was tested in EWI facility with the bench top prototype.

Part 2 of IPR took place on July Date: July 29 and 30th, 2003 in SOPAKCO Bennettsville, SC. Participants included: OSU (Howard Zhang), EWI (Alex Savitski), Natick (Peter Sherman), USDA (Richard Boyd, Jim Delmaine), DSCP (Jesse Burns), and SOPAKCO (Magdy Hefnawy, Bob Bishop, Dennis Stewart).

Dr. Howard Zhang and Dr. Alex Savitski participated in the R&DA Fall Meeting, November 3-5 in Biloxi, MS. The project team presented STP2004 as part of Session III-B Combat Operation Network Case Study. STP2004 was viewed as one of the flagship projects of CORANET program. This session was well attended. The project team met briefly after the case study session and went through conclusions of IPR#2. The team re-affirmed successful completion of Phase II and support moving into Phase III.

3.3. Phase III

3.3.1. Reinstallation

In February 2004, SOPAKCO removed the Bartelt machine from the production floor in an effort to reorganize the production facilities. Relocation of the ultrasonic sealing unit could not be scheduled until the Bartelt is put back in service.

In May 2004, the ultrasonic sealing unit was re-installed to replace the heat seal unit. Production evaluation initiated.

3.3.2. Production evaluations

Production evaluations were originally scheduled for 3 months. The project team agreed that it would be most beneficial to continue the evaluation, even though the CORANET STP2004 contract ended in October 2004.

In the month of May 2004, several lots of products were produced and evaluated. After passing the USDA inspection, SOPAKCO conducted production evaluation on a regular basis. Products, schedule and acceptance information are listed in Table 1.

4. Appendices

4.1. Request for proposals

DEFENSE LOGISTICS AGENCY HEADQUARTERS
8725 John Kingman Road, STE 2533
Fort Belvoir, VA 22060-6221
SENT BY FAX

IN REPLY
REFER TO: J-339

March 7 2002
Revised April 3, 2002

MEMORANDUM FOR DSCP-PBA: ATTN: Ms. Sue Bonanno

SUBJECT: Request for Proposal: Short Term Project: STP 2004, Implementation: Ultrasonic Sealing of MRE Pouches, Under the Combat Ration Network for Technology Implementation (CORANET II) OSU Partner Contract SPO103-02-D-0004.

1. Please request an official technical and cost proposal for performing tasks related to implementing Ultrasonic Sealing Technology in the production plant of an MRE producer, addressing actions as described in the attached statement of work.
2. The statement of work for the three-phased project to be performed by Ohio State University and other selected participants, is enclosed. Also attached is the Data Item Description for the Video Cassette Tape deliverable. The details of the draft proposal have been generally discussed, and this SOW addresses most of the concerns mentioned by JSG members. This is a formal request for a formal response.
3 For further information, please contact me on (703) 767-1417 (DSN 427-1417).

Encl
SOW
DID

RUSSELL EGGERS
PM/COTR CORANET

Statement Of Work

COMBAT RATION NETWORK FOR TECHNOLOGY IMPLEMENTATION

(CORANET II)

Implementation: Ultrasonic Sealing of Preformed Pouches In Production

SHORT-TERM PROJECT NUMBER STP-2004

C.1 BACKGROUND, OBJECTIVE, SCOPE AND DURATION:

C.1.1. Background

The results of CORANET I projects (STP1013 and STP1013A) have demonstrated that ultrasonic sealing is effective for bonding and sealing two layers of laminated film that is typically used in preformed MRE pouches. Prototype tests of preformed MRE pouches have been successful, and the feasibility of implementation into production has been reported as justified in terms of engineering and cost considerations for retrofitting at least one type of current filling and sealing machine. Also, a significant reduction in seal area defects is expected when ultrasonic sealing is implemented in regular production.

C.1.2. Objective

The objective of this project is to achieve a significantly increased yield of acceptable sealed pouches at a lower cost while maintaining or increasing current line speeds and reducing the occurrence of seal defects. The approach is to scale up and test the ultrasonic sealing technology in an actual production environment by retrofitting sealing capability and applying it to an existing production sealing machine found in industry. The target line speed for sealing pouches shall be from 40 to 60 pouches per minute, about comparable to current heat-sealing equipment, and quality defects in the sealed areas shall be reduced.

C.1.3. Scope and Duration:

This will be a three-phased project. Phase I will include bench-top optimizing of sealing parameters, as well as the identification of the kinds of ultrasonic sealing equipment needed for sealing in a real production environment, identifying production machines that can be refit to test out the concept, selecting the machine most receptive, designing of sealing equipment as a retrofit package, updating cost-benefit analyses, and providing recommendations and justifications in an In-Process-Review (IPR). There must be compelling evidence that Government investment in retrofitting the sealing machine selected for demonstration will be fairly applicable to many producers and advantageous to the Government. A cost sharing arrangement would be well received. Phase II will consist of acquiring the sealing equipment and installing it on an existing production machine, rewiring and programming the machine for controls and safety features to current standards, and calibrating or optimizing the sealing parameters for the materials to be sealed. Progress will be reported in an Interim Technical Report for the period, and a video cassette tape of the project will be provided as a deliverable at that time. Pending approval of the Program Manager, Phase III will be conducted to run production tests to collect data from real production and to demonstrate the expected improvements. The initial current sealing equipment selected will probably be a Bartelt filling machine because the integration of ultrasonic sealing devices with the in-line pouch flow is apparently easier, but the scope of this project is to identify other brands of sealing machines, and to determine time and costs predicted to retrofit each of them with Ultrasonic sealing devices. The effort will require selection of a plant production line to serve the purpose of long-term demonstration, and arranging with the owners to have them support the project during the entire evaluation period, including preparation of a final report at the end of the project. Please provide an estimated duration to perform this project within the formal proposals.

C.2. DEFINITIONS: To be provided by the performer.

C.3. APPLICABLE SPECIFICATIONS: MIL-P-44073 (Latest Version), Packaging and Thermoprocessing of Foods in Flexible Pouches

C.4. GOVERNMENT FURNISHED MATERIAL: None

C.5. CONTRACTOR FURNISHED PROPERTY: The contractor will furnish all material, personnel, and equipment to complete this project.

C.6. SPECIFIC TASKS

C.6.1. Task 1. Management Plan and Schedule

The contractor will prepare a Management Plan and Schedule (MPS) that includes a listing of anticipated tasks for all team members and partners involved. The MPS will show three phases and be used to manage and coordinate all activities necessary for the process implementation, maintaining and updating the MPS during the course of the project. Anticipate briefing progress at CORANET workshops, as well as in monthly progress reports.

C.6.2 Task 2. Optimize ultrasonic sealing process parameters for quad-laminate pouches

Conduct the process optimization for quad laminated retort pouches using the bench-top prototype sealing system developed in STP1013A. Use the results of peel tests and microscopic inspections of the seal area as criteria for the optimization of the sealing parameters, which will later be applied to the production equipment. This step is to be conducted at this time to minimize the interruption of production later on when the equipment is actually installed in a plant.

C.6.3 Task 3. Arrange for access to a "production" sealing machine.

Contact CORANET Partners to identify and arrange with one of them for access to a production-sealing machine for the conduct of this project. Special attention will be made to avoid major production conflict, and reasonable assurances can be provided in the language of the project. Assure that the facilities will be open for In-Process Reviews (IPR) and a final demonstration to JSG and the academic partners of CORANET II. As a substitute for actually seeing the retrofit in progress nor seeing the demonstration equipment, arrange to provide a video tape of those activities as part of the final report.

C.6.4 Task 4. Design the hardware and software for integration and retrofit

With the assistance of partners, identify the ultrasonic sealing equipment components and a suitable system configuration necessary for sealing pouches in production. Define requirements and evaluate available options with the equipment vendor. Identify and provide necessary process improvements when scaling up the technology from the bench-top prototype to the packaging line in an actual production environment. Oversee the design and manufacturing of the components to assure future fit and function when installed, and acquire the system.

C.6.5 Task 5. Implement the new ultrasonic sealing equipment

Upon Program Manager approval at the IPR, acquire, install and integrate the new ultrasonic sealing equipment onto the preformed pouch machine at the production site selected. Assure that the design and construction of the hardware and software, rewiring and programming for controls and safety features meet current standards. Plan to perform tuning and testing of the integrated system with minimum interruption to the production schedule.

C.6.6 Task 6. Calibrate and Optimize the ultrasonic sealing technology and train plant operators

Based on results of the Task 2, optimize the ultrasonic sealing process for quad-laminated pouches on the packaging line by scaling up the bench top processes to meet the production equipment needs. This effort must achieve an acceptable level of seal quality as soon as possible, and can then be improved if necessary over longer continuous production runs.

C.6.7 Task 7. Continue to monitor and adjust parameters as needed over a long term test period, to gain valid experience and to evaluate the performance

Plan for a statistically significant test run when the equipment is set up to run, and provide samples for evaluation and training. Plan to see the equipment accepted for production if the results are satisfactory. Subsequently, plan to monitor results over a longer time for experience and to evaluate the system performance and stability, and noting the frequency of making adjustments needed during the test period, thus demonstrating the results.

C.6.8 Task 8. Prepare a final report

Prepare a final report, with complete description of the technology and steps taken, a cost/benefits analysis, and recommendations on further implementation. Address also, how implementation might be accomplished with Partner cost sharing or other means.

C.7. Criteria For Measuring Effectiveness Of The Effort

This project will be considered effective if the objectives are met as intended in the estimated time period. A full In-Process-Review (IPR) will be scheduled after six months or as needed to review and critique the project at the end of Phase I, and to provide management direction as needed.

C.8. Deliverables

Demonstration of an operational ultrasonic sealing system integrated into pre-formed pouch packaging line is the primary deliverable. The format of the following deliverable data items will follow the Contract Data Requirements List (CDRL) for the CORANET contract. They are applicable to this STP, and will be used to enhance the objectives of the CORANET II program.

C.8.1. Monthly Progress Report (MPR)

Report updates on the MPS for this task under Short Term Projects of the Monthly Progress Report (concurrent with and part of CORANET CDRL Sequence A001).

C.8.2. Interim Technical Reports

Interim Technical Reports: Accumulate the specific task documentation required in Interim Technical Reports (CDRL Sequence A002), which, when combined, will be the basis for the Final Technical Report (CDRL, Sequence A003) for that specific task. In the event that a task grows beyond the scope of this project, another separate formal STP will be created to handle it.

C.8.3. Final Technical Report

Prepare one comprehensive final report to briefly cover all of the efforts in this STP during the entire first two-year performance period (CDRL Sequence A003). A technical videotape, as part of the final report, will document demonstration production run(s) and significant steps during retrofitting.

C.8.4 Video Cassette of Project Highlights

Provide a video cassette recording in VHS format of selected highlights of the project, for a 30 minute duration. Include informative before-and-after views of the equipment, the equipment in motion sealing pouches, and some contrasting views of product before and after sealing, suitable for training. A Data Item Description (DI-A-30037- Tailored by DLA) will be provided separately.

C.8.5 Work Unit Information Summary

Work Unit Information Summary (WUIS) at the beginning and at the end of this STP, in accordance with CDRL sequence A008, Research and Technology Work Unit Information Summary (WUIS).

4.2. Proposal

COMBAT RATION NETWORK FOR TECHNOLOGY IMPLEMENTATION (CORANET II)

SHORT-TERM RESEARCH AND DEVELOPMENT PROJECT STP-2004
Technical Proposal

Implementation: Ultrasonic Sealing of Preformed Pouches In Production

TO
Defense Supply Center Philadelphia (DSCP)
United States Department of Defense
DSCP-PBA – A. Bonanno
700 Robbins Avenue, Philadelphia, PA 19111
cc: Russell Eggers, DLA
Defense Logistics Agency, ATTN: DLA-MMPRT
8725 John J. Kingman Road, Suite 3135, Ft. Belvoir, VA 22060-6221

In Correspondence to RFP J-339

Submitted by: Principal Investigator:
Dr. Q. Howard Zhang, The Ohio State University
Co-Investigators:
Dr. Alexander Savitski, Edison Welding Institute
Mr. Peter Sherman, Natick Soldier Center
Mr. Jesse Burns, DSCP
Mr. Richard Boyd, USDA
Dr. Magdy Hefnawy, Unaka
Mr. Robert J. Helgerson, SOPAKCO

The Ohio State University Research Foundation
1960 Kenny Road, Columbus, OH 43210
April 19, 2002

Table of Content

1. BACKGROUND, OBJECTIVE AND SCOPE

1.1. Background

The results of earlier projects (STP1013 and STP1013A) have demonstrated that ultrasonic sealing is effective for bonding and sealing two layers of laminated film that is typically used in preformed MRE pouches. The initial study (STP1013) was conducted with participation of five leading ultrasonic equipment manufacturers, Branson Ultrasonics, Dukane Ultrasonics, Forward Technology, Sonics and Materials, and Sonobond. We identified the plunge welding method and the Dukane Ultrasonic's approach as a most promising for sealing of MRE pouches. Based on technical requirements developed by Edison Welding Institute (EWI), a bench top prototype system was designed and built by Dukane Ultrasonics. The system was successfully tested and used to evaluate a variety of conditions, and the results are very promising. Specifically, ultrasonic sealing seems to be very tolerable to seal area contaminants, thus avoiding defects that are frequently found in seals as they are currently sealed. Prototype tests of preformed MRE pouches have been successful. Ultrasonic sealed, preformed tri-laminate, pouches met or exceeded package-integrity requirements even with significant seal-area contamination. Ultrasonic sealing technology is ready for implementation in actual production of preformed MRE pouches.

Feasibility of production implementation was justified from the engineering and cost perspectives. It would be the easiest to implement in an in-line pouch package line, where the pouches travel in-line with the sealing mechanism (such as a Bartelt). Mechanical installation is simply to replace existing heat-seal station(s) with that of ultrasonic. A transverse line (such as a Mitsi) may also be retrofitted, where additional mechanism may be required to feed pouches through the ultrasonic sealing station. Cost analysis estimates the return of investment less than one year. Significant improvement to seal area defects is expected when ultrasonic sealing is implemented.

Building on the successful experience of earlier projects, The Ohio State University (OSU) and EWI team proposes to retrofit a preformed-pouch line as a technology demonstration. The US Army Natick Soldier Center, DSCP and USDA will assist the objective evaluations of production results.

SOPAKCO and Unaka Company are partners and provide a Bartelt line in their facility for this proposed implementation. SOPAKCO will also provide products, materials and production labor to assist the optimization and evaluation studies. These are significant cost share. A letter of support details these commitments. The successfully implemented ultrasonic sealing system will remain in SOPAKCO after the completion of this short-term project. Demonstration production run(s) and significant steps during retrofitting will be videotaped for the CORANET Program.

1.2. Objective

The objective of this project is to scale up and test the ultrasonic sealing technology in an actual production environment by retrofitting sealing capability and applying it to existing production sealing equipment found in industry. The target line speed for sealing pouches shall be from 40 to 60 pouches per minute, with significantly fewer quality defects.

1.3. Scope

This project will identify the ultrasonic sealing equipment needed for installation as a retrofit package, acquire that equipment and install it on an existing production machine, a Bartelt, rewire and program the machine for controls and safety features to current standards, and run production tests to demonstrate the expected improvements. A production line in SOPAKCO will serve the purpose of demonstration. A three-month evaluation period is programmed where samples will be collected periodically. OSU, EWI, Natick and USDA will evaluate samples.

Ultrasonic sealing or joining is a technology that utilizes ultrasound as a means of energy delivery to the interface of two pieces of plastics held together. The sound frequencies are in the range of 20 kHz to 40 kHz. This method of energy delivery has the advantage of higher temperature at the joining interface and lower temperature outside. This is in contrast to traditional heat-seal, where heat is conducted from the heated tool, through the package material to the joining interface. Heat-seal is prone to seal area contamination where contaminants limits the seal temperature, as heat transfer is limited by the thermal conduction of packaging, to that below the melting point of joining plastic materials, thus resulting in seal area defects. The hammering effect of ultrasound further helps expel seal-area contaminants. Ultrasonic sealing is known to enhance seal integrity of plastic materials.

STP1013 studied the feasibility of ultrasonic sealing to join tri-laminated foils. One inch-wide test strips were sealed with and without contaminants. Ultrasonic sealing demonstrated good seal strength even in the presence of seal contamination.

According to the recommendation of STP1013, STP1013A investigated the feasibility of ultrasonic sealing with a bench top prototype sealer. Preformed pouches were sealed with and without products, with selected source and level of seal-area contaminations. Sealing conditions for tri-laminated pouches were optimized. These projects point to the applications that ultrasonic makes the last seal. In many of the retort pouch making industry, pre-formed pouches are filled with product and the upper (fourth) seal is made after filling. This sachet type of pouches are prone to seal area contamination when a product has a liquid phase that is highly viscose, such as a soup product, a sauce product, or even a beverage type of product. In the vertical forming-filling-and-sealing operation of liquid food, the sealing process is designed to seal through the product to eliminate the headspace. In some of the pouch filling operation, steam is injected to the pouch after filling to increase the temperature and drive off air. The condensed steam, as water droplets, also cause seal defects in current heat-seal units. Ultrasonic sealing is a good candidate for making the last seal through the product, or after filling and steam injection. A major food package company already utilizes ultrasonic sealing to make the last seal of a vertical-form-and-seal process of liquid beverage in a laminate-paper brick style package. Economic analysis in STP1013A shows significant benefit of implementing ultrasonic sealing to a pre-formed pouch line. The estimated Return-of-Investment (ROI) is less than one year. Economic model spreadsheet provided industry first hand estimates of cost savings and improvement in product quality.

It is time to capitalize the investment of CORANET program in previous short-term projects. This return is only possible when ultrasonic sealing is implemented in the ration industry. As with any other emerging technologies, an implementation in actual production requires courage, planning, design and careful execution. There are two approaches in demonstrating the efficacy of a technology, implementing in a test (demo) facility or implementing in an actual production facility. The proposal team has carefully considered both approaches and chose the implementation in a production facility. This is the ultimate goal of a production technology. It is only through such implementation, ultrasonic technology will benefit the ration industry, the military ration program, and in turn, our war fighters.

The project team and industrial partners understand the challenges and benefits. The implementation site will take the challenge and should receive the benefits. We believe that the ultrasonic system, once successfully implemented, becomes an integral part of the pre-formed pouch line and it should remain so at the completion of this project. The retrofit design, specification, optimization studies, and evaluation results belong to CORANET and the Federal government. Other CORANET partners may choose to implement ultrasonic sealing to their lines while further tuning may be required for best performance.

Duration: 18 months. Stating date: May 1, 2002.

2. DEFINITIONS

None

3. APPLICABLE SPECIFICATIONS

None

4. GOVERNMENT FURNISHED MATERIAL

None

5. CONTRACTOR FURNISHED PROPERTY

The contractor will furnish all material, personnel, and equipment to complete this project.

6. SPECIFIC TASKS

Phase I. Preparation

6.1. Management Plan and Schedule

The principal investigator (Howard Zhang, OSU), in collaboration with EWI, SOPAKCO, and government liaisons, will prepare a Management Plan and Schedule (MPS) that includes a listing of anticipated tasks for all team members, subcontractors and partners involved, including OSU and EWI staff, industrial partners, ultrasonic equipment vendor, the system integrator, Natick, DSCP and USDA. OSU and EWI will provide management and coordination of all activities necessary for the process implementation, maintaining and updating the MPS during the course of the project. We will provide update briefings to the CORANET II Partners at workshops on the project progress. A phase approach will be taken to ensure coordination and success.

6.2 Optimize ultrasonic sealing process parameters for quad-laminate pouches

The process optimization will be conducted in EWI lab using the bench-top prototype sealing system developed in STP1013A. Peel test and microscopic inspection of the seal area will be used as criteria for the optimization of the sealing parameters. A significant number of pouches (up to 400) will be sealed, retorted and submitted to USDA and Natick for their evaluations. Optimized parameters will be used in the production test. Based on these evaluations, USDA and Natick will make necessary recommendations/revisions to current inspection criteria to permit the use of ultrasonic sealing of preformed pouches.

6.3 Arrange for access to a production sealing machine

Arrangement will be made with partners SOPAKCO and Unaka for access to a production-sealing machine for the conduct of this project. Special attention will be made to avoid major production conflict. In-process reviews and a final demonstration will be open to JSG and academic partners of CORANET II, while videotaped for other CORANET partners.

6.4 Design the hardware and software for integration and retrofit

With the assistance of partners, the OSU/EWI team will identify ultrasonic sealing equipment components and a suitable system configuration necessary for the pouch sealing in production. Define requirements and evaluate available options with the equipment vendor. Identify and provide necessary process improvements when scaling up the technology from the bench-top prototype to the packaging line in an actual production environment. Cost estimates will be obtained for retrofitting all existing pouch lines. Design work will focus on an in-line pouch machine (a Bartelt). An In-Process-Review will be conducted prior to moving into Phase II.

Phase II. Implementation

6.5 Procure and Install the new ultrasonic sealing equipment

Oversee the manufacturing of the components and acquire the system. Install the new ultrasonic sealing equipment onto the preformed pouch machine at the SOPAKCO production site. The EWI team will identify the system integrator and coordinate and oversee installation activities. The system integrator will be responsible for the design of the hardware and software for integration of the ultrasonic sealing system components into the packaging machine; rewiring and programming the packaging line for controls and safety features to current standards; run production tests with the plant representatives, EWI and ultrasonic system vendor; and provide services and repair on as-needed basis. EWI team will perform tuning and testing of the integrated system. At the end of tuning process, the ultrasonic sealing unit should perform normal seal function at the speed of the line.

6.6 Optimize the ultrasonic sealing technology and train plant operators

Based on results of the Task 2, optimize the ultrasonic sealing process on the packaging line. In collaboration with the equipment vendor and system integrator organize and conduct training sessions for the plant technical personnel for continuous operation. Limited scope production runs will test and evaluate pouches sealed under process-optimized conditions. A significant number of pouches (up to 400) will be submitted to USDA and Natick for their evaluations. Process approval will be made by SOPAKCO in consultation with recommendations/revisions by USDA and Natick. An In-Process-Review will be conducted prior to moving into Phase III.

Phase III Evaluation

6.7 Conduct a long time test run for experience and evaluate the performance

Conduct a long-time test run for experience and evaluate the system performance, making adjustments if needed during a test period, thus demonstrating the results. System will be monitored for a minimum of 3 months of production, while the samples will be gathered and evaluated. Proposed quantity is 400 samples each month randomly collected. Seal area microscopic inspection and peel test will be conducted in EWI with 10% of samples, and the rest of the samples provided for OSU, USDA and Natick for additional evaluations.

6.8 Prepare a final report

Prepare a final report, with complete description of the technology and steps taken, a cost/benefits analysis, and recommendations on further implementation. We will address also, how implementation might be accomplished with Partner cost sharing or other means.

7. CRITERIA FOR MEASURING EFFECTIVENESS OF THE EFFORT

This project will be considered effective if the objectives are met as intended in the estimated time period. A full In-Process-Review (IPR) will be scheduled after six months or as needed to review and critique the project, and to provide management direction as needed.

8. DELIVERABLES

Operational ultrasonic sealing system integrated into pre-formed pouch packaging line. In addition, the format of the following deliverable data items will follow the Contract Data Requirements List (CDRL) for the CORANET contract. They are applicable to this STP, and will be used to enhance the objectives of the CORANET II program.

8.1. Monthly Progress Report (MPR)

Report updates on the MPS for this task under Short Term Projects of the Monthly Progress Report (concurrent with and part of CORANET CDRL Sequence A001).

8.2. Interim Technical Reports

Interim Technical Reports: Accumulate the specific task documentation required in Interim Technical Reports (CDRL Sequence A002), which, when combined, will be the basis for the Final Technical Report (CDRL, Sequence A003) for that specific task. In the event that a task grows beyond the scope of this project, another separate formal STP will be created to handle it.

8.3. Final Technical Report

Prepare one comprehensive final report to briefly cover all of the efforts in this STP during the entire first two-year performance period (CDRL Sequence A003). A technical videotape, as part of the final report, will document demonstration production run(s) and significant steps during retrofitting.

8.4 Work Unit Information Summary

Work Unit Information Summary (WUIS) at the beginning and at the end of this STP.

Table 1. Project Tasks and Milestone Chart.

Tasks	
Phase I	
Task 1	Month 1 – 2, update regularly
Task 2	Month 1 - 4
Task 3	Month 1 – 2, reconfirm when needed
Task 4	Month 1 - 7
Phase II	
Task 5	Month 8 or 9
Task 6	Month 9 and 10
Phase II	
Task 7	Month 11 – 16, with three-month schedule flexibility
Task 8	Month 17 and 18

4.3. EWI Subcontract Final Report

(Separate file)

4.4. Demonstration videos

DVD or CD files are available up on request to Mr. Jesse Burns.

MATERIALS JOINING TECHNOLOGY

November 23, 2004

Q. Howard Zhang
OSU Food Science and Technology
2015 Fyffe Road
Columbus, OH 43210

EWI Project No. 46179CSP, "Ultrasonic Sealing of Preformed Pouches - Production Floor Testing"

Dear Howard:

Enclosed is EWI's report for the above referenced project. If you have any questions or comments, please contact Marc St. John (614-688-5219) or Tim Frech (614-688-5113) at EWI regarding this project.

Sincerely,

Alexander Savitski
Senior Engineer
Microjoining & Plastics

Enclosure

REPORT

November 19, 2004
EWI Project No. 46179CSP

Ultrasonic Sealing of Preformed Pouches - Production Floor Testing

Submitted to:

OSU Food Science and Technology
Columbus, OH

EWI®

MATERIALS JOINING TECHNOLOGY

Report

Project No. 46179CSP

on

Ultrasonic Sealing of Preformed Pouches - Production Floor Testing

to

OSU Food Science and Technology
Columbus, OH

November 19, 2004

Alexander Savitski
EWI
1250 Arthur E. Adams Drive
Columbus, OH 43221

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1.0 Introduction

The results of earlier projects have demonstrated that ultrasonic sealing is effective for bonding and sealing two layers of laminated film that is typically used in preformed meals ready-to-eat (MREs) pouches. The initial study conducted with participation of five leading ultrasonic equipment manufacturers (Branson Ultrasonics, Dukane Ultrasonics, Forward Technology, Sonics and Materials, and Sonobond) identified the plunge welding method and the Dukane Ultrasonics' approach as a most promising for sealing of MRE pouches. Based on technical requirements developed by EWI, a bench-top prototype system was designed and built by Dukane Ultrasonics (EWI Project No. 43582CSP, Coranet STP1013A). The system was successfully tested and used to evaluate a variety of conditions, and the results are very promising. Specifically, ultrasonic sealing seems to be very tolerable to seal area contaminants, thus avoiding defects that are frequently found in seals as they are currently sealed. Prototype tests of preformed MRE pouches have been successful, and the technology seems ready for implementation in actual production.

2.0 Objective

The objective of this project was to scale up and test the ultrasonic sealing technology in an actual production environment by retrofitting sealing capability and applying it to existing production sealing equipment found in industry.

3.0 Phase 1

3.1. Project Planning Meeting

Project planning meeting and packaging process review at Bennettsville production site was facilitated by OSU and EWI and held on July 23 and 24, 2002. DLA, Natick, Unaka, SOPACKO, OSU, EWI, Chase Machine & Engineering, and Dukane Ultrasonics representatives participated in the meeting.

Project planning minutes are included in Appendix A.

3.2 Process Optimization

3.2.1 Materials and Equipment

3.2.1.1 Materials

Preformed quad-laminated MRE pouches and pouches with food for the process optimization experiments and ultrasonic sealing process testing have been provided by Sopakco. The preformed pouches were already heat sealed on three sides, while the fourth side was left open for food filling and the final ultrasonic seal.

Materials from two approved Sopakco vendors (Smurfit – main producer and Pechiney – alternative producer) were tested in the study. Process optimization experiments were conducted using the main, Smurfit material, although at the process-testing phase, both types of packages have been sealed and sent for evaluation to USDA, Sopakco, and Natick.

- Original batch - Smurfit material:
  - Measured overall pouch thickness (top + bottom layers): 0.0120 in.

- Alternative material:
  - Pechiney: Measured overall pouch thickness (top + bottom layers): 0.0120 in.

Based on Sopakco information, both materials have the same 0.00558-in. nominal thickness, composed of the following layers:

- 0.00048-in. polyester
- 0.00060-in. bi-ax-oriented nylon
- 0.0005-in. aluminum foil
- 0.004-in. polypropylene.

3.2.1.2 Equipment

The process optimization study was conducted at EWI using the bench-top prototype ultrasonic sealing system (Figure 1) developed previously by EWI and Dukane Ultrasonics (EWI Project No. 43582CSP, Coranet STP1013A).

The system consisted of two major components:

- Horizontally positioned Dukane 20-kHz 2-kW Millennium 2200-Series Dukane ultrasonic welder with ½- × 7-in. horn with flat face.

- A pouch-holding assembly (Figure 2), that included a pair of clamps for securing the pouch in a sealing position and a ½- × 7-in. stainless steel medium female knurl anvil, positioned against the top part of the pouch.

Both the welder and the pouch-holding assembly were mounted on a separate leveling plates, which made it possible to adjust the position of these two components so they would be precisely aligned in horizontal and vertical planes.

Peel tests were conducted on a TCM 210 Chatillon tension tester (Chatillon, Greensboro, NC).

3.2.2 Welding Trials

Process parameters optimization for the quad-laminate pouches was conducted in two phases:

- Phase 1 was focused on the system alignment and set-up for specific material thickness.

- During Phase 2, a design-of-experiment (DOE) approach was used for ultrasonic parameters optimization. The full-factorial design model with two variables, energy output and hold time, was selected for developing the experiment matrix.

Based on industry experience in ultrasonic welding of films and laminates and the material weldability data generated in EWI Project No. 43582CSP, the energy control mode was selected for the optimization experiments. With the energy output as the selected process control mode, the system welds until the generator delivers specified amount of energy to the transducer while the horn is in contact with the part. The data generated during EWI Project No. 43582CSP project was used in setting a preliminary range from 400 to 1000 J for the energy output parameter in the first run of the DOE. The second parameter, effect of which was evaluated during the trials, was hold time (the time during which the joint is cooled under the pressure). Hold time varied from 0 to 0.9 s. Welding trials were conducted using a 2:1 ratio booster and 90% amplitude.

Based on client specifications, the mechanical quality of the seals was evaluated based on the results of the peel test; and the peel test results were used as a response factor in the DOE. To test the seal, three 1-in.-wide specimens (one from the middle and two from the left and right peripheries) were cut from the sealed pouch and subjected to the peel test. During the peel test, two tails of the specimens were clamped and pulled in opposite directions until the seal was broken (Figures 3, 4, and 5). The peel strength value for each specimen, the average peel strength value, and the failure mode (seal failure or the parent material failure) were recorded.

Another factor used for the ultrasonic seal evaluation was appearance of the seal area. The acceptance criteria for the seal area appearance was absence of damage to the substrate material. All samples were inspected under a microscope to evaluate possible material damage that could have resulted from ultrasonic welding. Photographs were taken of the samples representative of a good seal or a seal with material damage.

The experimental matrix for the first run of the DOE is presented in Table 1. The matrix includes:

- Run order of the experiments
- Two control parameters settings (energy and hold time)
- Selected essential readings of the other ultrasonic sealing parameters (peak power, absolute distance, weld distance, weld time)
- Joint evaluation results.

Based on the results generated in the first run of the DOE, the second matrix with the narrowed-down variables ranges was designed. In the second run of the DOE the energy varied from 600 to 800 J and the hold time from 0.3 to 0.9 s. Table 2 presents the welding trials data generated on the second run of the DOE.

3.2.3 Optimization Results and Discussion

As expected, based on its composition and previously generated experimental data (EWI Project No. 43582CSP, Coranet STP1013A), the quad-laminate-preformed pouch material demonstrated good weldability.

The analysis of the peel test results shows that with the increase of energy input and hold time, the peel strength increased initially; but starting from the 600-J energy level and 0.3 s, it reached the strength of the parent material (~17 lb/in.). Further variations in the peel strength readings (ranging from 17 to 21 lb/in.) can be attributed only to deviations of the failure load of the substrate. The results of sealing trials conducted at a 600-J energy level and higher have demonstrated good consistency, and 100% of the samples produced at these setting failed through the parent material at all three locations of the seal area tested (Figures 3, 4, and 5). Non-optimized seals fail partially through the seal area, as shown in Figure 6. At the same time when the energy input was set at 1000 J, some local damage to the laminate in the seal area was observed. This observation and the peel test results coincide with the sealing trials data generated in EWI Project No. 43582CSP on tri-laminate preformed packages. As it was reported in EWI Project No. 43582CSP (Coranet STP1013A), the seals of consistently good quality were produced in the range of 650 to 850 J, and the risk of damaging the material increased at higher energy levels. The 3D peel strength vs. energy and hold time surface plot summarizing the results of the first run of the DOE is presented in Figure 7, and the main effects plot detailing the effect of each of the variable on the peel strength is presented in Figure 8.

To further refine results generated in the first run of the DOE and identify the optimum windows of process parameters, the second matrix was designed with the narrowed-down variable ranges. Based on the results of the first run, the 400- and 1000-J energy levels were dropped from the matrix, so the energy was varied from 600 to 800 J with 100-J increments. The hold time was varied from 0.3 to 0.9 s, since only the 0-s hold time was associated with reduced peel strength of the seal. The sealing trials results generated in the second run of the DOE are presented in Table 2 and, as it is apparent from the data, it was not possible to differentiate between different energy and hold time levels in the tested ranges since all of the samples produced in the second run had consistently high quality. 100% of specimens cut from all three locations of the seal have failed through the substrate when subjected to the peel test. No material damage was observed during the microscopic inspection of the seal area (Figure 9).

The results of the sealing trials demonstrated that it is possible to produce sound seals in the range of 600 to 800 J; however, it was suggested that continuous testing of the process, while preparing the samples for USDA and Natick evaluation, might produce additional data valuable for further refinement of the optimum energy level. Such sample preparation involves sealing the pouches filled with the product and retorting them and, as it was observed during EWI Project No. 43582CSP, different energy input may affect the material's resistance to de-lamination during the retorting process. Based on this, it was decided to use 600- and 700-J energy levels when sealing filled pouches and to observe whether different energy settings would render any differences in seal quality. Since the test results did not discriminate between seals produced with different hold times in the tested range of 0.3-0.9 s, it was decided to recommend a 0.3-s hold time for the sample preparation phase in order to minimize the production cycle time.

3.2.4 Sample Preparation for USDA and Natick Evaluation

To demonstrate the ultrasonic sealing process for MRE production, 248 pouches with different types of food products in them were ultrasonically sealed, retorted, and submitted for inspection by USDA, Natick, and Sopakco. 10% of the pouches were tested at EWI and 10% provided to OSU Food Science and Technology. Most of the testing (228 packages) was conducted using Smurfit packages that Sopakco primarily uses in production. 20 Pechiney-produced pouches were also sealed, retorted, and submitted for inspection, after it was verified that the optimized settings are applicable for this alternative material. These pouches have the letter “P” following their number.

The ultrasonic sealing parameters were set based on the results of the process optimization study that were reported in Section 4.2. As in the process optimization experiments, sealing of filled pouches was conducted in an energy-control mode, since this mode is generally used in industrial conditions. Initially, the energy output was set at 600 J, and first 80 pouches were sealed at this energy setting. After that, the energy was raised to 700 J and maintained this level. The energy was increased based on visual inspection of the seals and initial evaluation results.

The MRE sample-preparation procedure included the following steps:

- Packages with the food provided by Wornick were opened.
- Food was transferred from the packages to new pouches.
- Pouches filled with the food were secured in the pouch holder, sealed ultrasonically in the energy mode, and process parameters were recorded.
- Sealed pouches were stored in refrigerator before retorting.
- The pouches were retorted at 250°F for 20 min with a outer pressure of 28 psi.
- Retorted pouches were stored at room temperature, packed in the box and shipped to USDA, Natick, and Sopakco.

Samples were marked with numbers for identification (Figure 10). The seal surface was inspected visually to ensure that the seal was uniform and that the seal area was free of material damage. After the pouches were retorted at OSU, 10% of them were brought back to EWI, cut open, emptied, cleaned by rinsing them with water, and subjected to the peel test. To ensure seal consistency 1-in.-wide specimens for the peel test were taken from the center and from the both ends of the seal. The peel strength value of each specimen was recorded and the average peel strength calculated.

The sealing process settings and peel test data generated by testing 10% of retorted pouches are presented in Table 3. As it was noted above, based on initial evaluation of the seals, which included visual inspection of the seal area and the peel test, it was concluded that the 700-J energy setting provides better consistency in the seal quality. This can be explained by the fact that manual filling of the pouches resulted in the bulking content and some difficulties in bringing two sides of the pouch in contact in perfectly parallel fashion. Higher energy input helps to mitigate the influence of not perfectly aligned or somewhat stressed layers to be sealed and assured a more robust sealing process. As it is evident from the peel test data, at the 600-J energy setting, some of the tested seals had reduced peel strength at the periphery of the seals, but once the energy input was increased from 600 to 700 J, the consistency of the peel strength improved, and all of the tested specimens failed through the substrate. This data combined with the results of the visual inspection of the seal area has demonstrated that the 700-J energy setting assured uniform quality of the seal, and it was decided to keep the current settings (700-J energy, 0.3-s hold time) for producing all remaining samples.

3.3 Production Process Review

The project team has reviewed four types of MRE pouch machines and evaluated the technical feasibility of retrofitting them with ultrasonic sealing equipment components. Based on the review results, it was concluded that all of the machines that were inspected at Sopakco (Bennettsville) could be retrofitted with ultrasonic welding technology. No technical obstacles preventing future modifications were discovered by Chase Machine & Engineering (a company specializing in integrating ultrasonic systems in production lines) and Dukane Ultrasonics (a manufacturer of ultrasonic welding equipment).

This conclusion was independently confirmed by Klockner Bartelt (Bartelt packaging line manufacturer) that states that “U/S sealers could readily be designed in to be a 'trade-out' for the currently quoted pre-heat and heat sealers. If for some reason it was felt necessary to go back to heat sealing, the heat sealing assemblies could be retro-fitted”.

3.4 Integration Cost Estimate

Based on the production process review results, cost estimates were requested and obtained from the system integrator for retrofitting all existing pouch lines:

Estimated pricing for the retrofit:

	Cost ($)
Bartelt Food Pouch Machine (quote)	25,200
1× Rotary Pouch Machine	*25,000*
2× Rotary Pouch Machine	*30,000*
Mitsubishi	*30,000*

Based on Chase Machine and Engineering's (Chase M&E's) estimate, the installation for each above module would be around $5,000.

The estimate has been discussed with the project team and sponsors and the decision was made to proceed with the integration design.

4.0 Phase 2

4.1 System Design

Requirements for the system integration and for ultrasonic sealer components were specified based on the packaging process review and on the input from Sopakco, UNAKA, and Klockner Bartelt. The requirements included:

- Installation requirements
    - The installation of the ultrasonic seal equipment should not interfere with the existing heat sealer. The switchover time from the ultrasonic sealer to the heat sealer should be as short as possible.
    - Power requirement: currently the Bartelt machine uses 480 VAC. However, if ultrasonic seal equipment will be on a separate platform, the power supply could be 208 or 480 VAC.

- Operational and maintenance requirements
    - Operation and maintenance should be easy and friendly. The target production line speed should be compatible with the currently operated heat sealer (40 cycles per minute).

- Requirements to the material
    - All parts used for the retrofitting shall be of non-corrosive materials, preferably stainless steel.
- Sanitation and water protection requirements

- Equipment must meet sanitation requirements of 9 CFR 416.3 Equipment and Utensils.
  - Equipment and utensils used for processing or otherwise handling edible product or ingredients must be of such material and construction to facilitate thorough cleaning and to ensure that their use will not cause the adulteration of product during processing, handling, or storage. Equipment must be maintained in sanitary condition so as not to adulterate product.
  - Equipment and utensils must not be constructed, located, or operated in a manner that prevents FSIS inspection program employees from inspecting the equipment or utensils to determine whether they are in sanitary condition. The equipment must also meet 9 CFR 416.4. To summarize – Sopakco personnel have to be able to clean food contact and non-food contact surfaces as often as necessary to prevent adulteration. The ultrasonic seal equipment should be protected from water during the wash down. The vendor should advise regarding cleaning procedures and any chemicals that could damage the equipment.

These requirements along with the system technical requirements, identified based on the results of STP1013A were communicated to Chase M&E and the ultrasonic component vendor, Dukane Ultrasonics.

Technical and operational requirements for the sealing system were reviewed with Dukane Ultrasonics, and because of this review, ultrasonic sealing components and suitable system configuration necessary for sealing pouches were specified based on user's requirements and best industry practices in ultrasonic sealing implementation. At that time the quotation and delivery time estimate for the component manufacturing were requested from Dukane Ultrasonics.

Once the components and the system configuration were finalized, the order was placed to Chase M&E for the integration module design. Necessary consultations were provided to Chase M&E during the module design phase and the complete design was reviewed and approved by EWI.

During the in-process review the quotes received from vendors responsible for the system integration and supplying ultrasonic components were approved by the project sponsors, which allowed EWI to place the orders for fabrication of the integration module and for manufacturing the ultrasonic system components.

4.2 Fabrication of the Integration Module and Procurement of Ultrasonic Components - System Installation and Testing

4.2.1 Module Fabrication and Testing

After the issuance of orders for fabrication of the integration module and for manufacturing the ultrasonic system components, EWI has facilitated communication between two vendors, providing necessary technical consultation and coordinating-related activities to assure consistency in engineering approach and schedule synchronization during the system manufacturing. The schedule synchronization task was especially critical for completing the system-fabrication phase within the planned timeframe, particularly in case of the custom-designed anvil, which was designed and machined at the Chase M&E facility, then sent to Dukane Ultrasonics to put a knurl pattern on the block face and sent back to Chase M&E for final assembly. EWI provided technical consultations for the knurl design and coordinated Dukane Ultrasonic's and Chase M&E's activities to deliver it in time.

Once manufactured, Dukane Ultrasonic's ultrasonic components were shipped to the Chase M&E facility where final assembly of the ultrasonic sealing module took place. The assembled module is shown on Figure 12. The module incorporates:

- 20-kHz probe system with stainless steel enclosure, air cooling and ½-in. 20-threads Military Spec connector, mounted on horizontal plate.
- Stainless steel anvil with fine female knurl mounted on adjustable leveling plate and equipped with the travel adjustment module with adjustment screw.
- 2:1 titanium heavy duty booster.
- ½- × 7¼-in. 20-kHz titanium flat-faced horn with radiused edges and ½-in. "pads" on each side 0.0005-in. tall to accommodate difference in pouch thickness at manufactured seal area.

The unit is powered by a 2200-W Level 1 DPC generator with time and energy control and has enclosed pneumatic and electric control boxes.

As requested by EWI, a comprehensive system testing and initial process optimization took place at the Chase M&E facility on March 4-6, 2003 with the presence of a Dukane Ultrasonic representative.

The testing and initial process optimization was conducted by an EWI engineer with the assistance of Chase M&E technical staff. As with the prototype system, the process optimization was conducted in two phases (during Phase 1 the system alignment and set-up for specific material thickness was completed). This phase has included the following steps:

- Building a temporary pouch-holding fixture for sealing process testing
- Vertical and horizontal horn and anvil precise alignment
- Circuit and controllers testing
- Ultrasonic sealing process testing
- One of the two horns' surface modification, based on initial test results

Phase 2 of the testing was focused on preliminary optimization of ultrasonic parameters. Data generated during the process optimization phase, when the process parameters were optimized on the bench-top prototype system, was used as the starting point of optimization process. However, considerable differences in the design of the production module and bench-top prototype resulted in differences in energy setting limits (450-580 J), within which acceptable seals were produced (in the production module, the probe system design was adopted and the horn fixed and the anvil movable. The probe system does not have a linear encoder, different anvil and horn designs, different tape on the face of the horn, etc.).

After the testing and preliminary process optimization was complete, the system was released to be shipped to Sopakco plant at Bennettsville, SC.

4.2.2 System Installation

4.2.2.1 Installation Plan Development

The draft of the system installation plan was developed in coordination with the technical staff of Chase M&E and later was reviewed and approved during the conference call on March 21, 2003 with all parties involved in the installation.

Parties involved in the installation plan discussion:

- Sopakco (Dennis Stewart - Operations Manager and Larry Parham - Maintenance Supervisor)
- OSU (Q. Howard Zhang)
- EWI (Alex Savitski)

- Chase M&E (Julian Rokicki and Brian Zust)

The following installation plan was reviewed and approved by the project team:

- Proposed installation date was Monday, April 21. This date was confirmed as available for Chase M&E, EWI, Sopakco, and Dukane.

- Chase will ship the unit to Sopakco in advance. Chase M&E technician, Brian Zust, will arrive on Sunday, April 20, to start the installation on Monday, April 21.

In order to speed up the final installation process and to minimize impact on production schedule, it was agreed that the installation will be carried out in two phases:

- **Pre-Installation Phase** that should be performed by Sopakco prior to the arrival of Chase M&E technician. Chase M&E will provide required guidance and advice over the phone. That part could be done for convenience for Sopacko scheduled shutdowns for the line maintenance and cleaning to minimize impact on production. The pre-installation phase will include:

  - Mounting of the pneumatics panel above the wash down area of the line.
  - Placing the Dukane Ultrasonics power supply unit away from the wash-down area. (Make sure that the communication cables reach the control box.)
  - Running conduit for the power cable from the control box to the Dukane Ultrasonics power supply.
  - Running a separate conduit from the control box to the Dukane Ultrasonics power supply for the communication cables.
  - Pulling and preparing for connection power and communications cable, *without making an actual connection*.
  - Running air supply to the pneumatics panel.
  - Running main power to the control panel.
  - Mounting the electrical control box near the plunge welder area.

- **Final Installation.** A Chase M&E technician, with support from plant personnel, will conduct the final installation. A plant technician and electrician should be made available to assist in the final installation.

4.2.2.2 System Installation

After the pre-installation phase was completed by Sopakco personnel, the integration of the ultrasonic module into packaging line took place on April 21-24, 2003.

- Installation team:
  - Sopakco: Magdy Hefnawy and Bob Bishop
  - EWI: Alex Savitski
  - Chase M&E: Brian Zust
  - Dukane Ultrasonics: Alan Baxter

- Steps completed during the final installation:
  - Installation of the ultrasonic sealing module and wiring
  - Installation of the cooling system, including additional external cooling for horn and anvil (Figure 15)
  - Preparation of the welder for testing and tune up

Installed ultrasonic sealing module is shown on Figure 13.

4.3 Equipment Set Up, Sealing Process Optimization and Personnel Training

After the installation, the welder was tuned and tested extensively. Initial process optimization and collecting samples was completed. This phase was carried out by EWI and Chase M&E in the presence of Dukane Ultrasonics representative and Sopakco maintenance personnel. This phase included the following steps:

- Aligning ultrasonic welder components and checking horizontal and vertical parallelism
- Setting a proper travel distance for the anvil
- Aligning pouch and welder position
- Adjusting the packaging line speed to 28-31 pouch/min
- Process settings optimization
  - Setting up energy (450 J), amplitude (95%), and pressure (65 psi)
- Initial test run and seal assessment. Sample pouches filled with 8-oz “chili and macaroni” product were collected during the 4-hr run
  - 18 samples were taken every 10 min
  - Sampling points from 1 to 24

Training on the new system was provided to Sopakco technical personnel:

- Continuous training of maintenance personnel and operation technicians by Chase M&E, EWI, and Dukane Ultrasonics during the installation and process setting (Figure 14).

- One training session by Dukane Ultrasonics and EWI with the plant maintenance manager, maintenance technicians, and QC director.

4.3.1 Test Run Results and IPR II Recommendations for Process Refinement

The following test run results were prepared by Sopakco and reviewed and evaluated by the project team:

			Pouches
Total product			5578
Samples collected for inspection			423
Defect pouches			141
Run 12:30-2:30			
	Entrapped matter	31	
	Yielding seal	45	
	Open seal	5	
	Foldover	5	
	Slant seal	2	
	Delamination	1	
Run 5:00-7:00			
	Entrap matter	12	
	Wrinkled seal	9	
	Foldover	1	
	Yielding seal	1	

In-Process-Review II (IPR II) has been scheduled and took place on May 14 and 15, 2003 at the Bennettsville facility, at which time the test run results were reviewed and evaluated:

Team observations and conclusions, based on the test run:

- The installation of the ultrasonic sealer was performed with minimum difficulties.
- The optimization process of the sealer was conducted to achieve an acceptable seal integrity.
- The process demonstrated to be easy to monitor and control.
- It was obvious that the machine at the end of the 4-hr trial run performed significantly better than the first 2-hr run.

    - 118 vs. 23 pouches

USDA and Natick completed pouch evaluations and provided the results to the project team. EWI made recommendations for further process refinement.

Based on the test run results, the project team developed an action plan to further refine the process. This plan included:

1. Add air cooling for both sides of pouch after the ultrasonic seal. Sopakco to add air cooling and test for:
   - Reduction in seal surface temperature to that similar to heat seal
   - Reduced or eliminated wrinkle problem
   - If not successful, proceed to V.2.
2. Add liquid cooling to seal area after ultrasonic seal. Sopakco to add a liquid mist/spray cooling to both sides of pouch.
   - At Location 5
     - Test for reduced seal surface temperature prior to release
     - Test for reduced or eliminated wrinkles
     - If not successful, proceed to V.5.
3. Modify the chute design. Sopakco to redesign a pouch release and chute so that the impact to the pouches reduced. A curved ramp with cushions may be helpful. This will help both heat and ultrasonically seal.
4. Consider relocation of ultrasonic seal to heat seal location and use cooling bar.
   - Sopakco will work alone or with Chase M&E to relocate the ultrasonic seal horn/anvil assembly to Location 2, to replace the heat seal mechanism. This will require decommissioning the pouch line for a period of time. This will also provide an objective evaluation of the ultrasonic seal, not only for the added time of cooling, but also potential reduction of cycle time to speed up production.
5. OSU and EWI to find/develop alignment tool(s) to assist operators in welder maintenance.

4.4 Packaging Process Refinement and Short-Term Packaging Line Testing

4.4.1 Follow-Up Actions at Sopakco Plant

As per action plan, an independent air cooling line was installed on the machine at the Sopakco Bennettsville facility with a wide, dual-opening nozzle to deliver air to both sides of the ultrasonic pouch seal.

On June 17, 2003 the Sopakco team conducted a trial run using the ultrasonic seal on the Bartelt machine line-8 at Bennettsville plant. The purpose of the trial was to assess the feasibility of incorporating an air cooling line, immediately after the ultrasonic sealer, to reduce pouch temperature in attempt to eliminate the wrinkles defect that observed during installation/optimization production run.

Based on the Sopakco information, the Bartelt machine operated at the speed of 32 pouches/min. Pouches were inspected, retorted, and re-inspected after retorts for defects.

Four cases (72 pouches) were pulled from the trial run and a case was sent to USDA and Natick for evaluation.

During the project review and update that took place at the Coranet II workshop in Chicago, the Sopakco latest test run results have been reviewed and the decision was made to proceed with additional test runs on July 29 and 30, 2003, which was confirmed by Sopakco management. The plan for the test run has been developed and finalized by the team during a conference call on July 21.

4.4.2 In-Process-Review (IPR) II Part 2. July 29 and 30, 2003 Test Run

The test run and IPR II, Part 2 meeting took place at the Sopakco facility as scheduled, on July 29 and 30, 2003:

Summary of the meeting agenda:

Date: July 29 and 30, 2003
Location: Sopakco Bennettsville
Participation: OSU (Howard Zhang), EWI (Alex Savitski), Natick (Peter Sherman), USDA (Richard Boyd, Jim Delmaine), DSCP (Jesse Burns), Sopakco (Magdy Hefnawy, Bob Bishop, Dennis Stewart)

1. The conclusions and recommendations from IPR II Part 1 have been reviewed by Howard Zhang

2. The status of recommended options from IPR II Part 1 Sopakco/OSU have been reviewed:
   - Added air cooling to seal surface – done and eliminated wrinkles

- Add liquid cooling - deferred
- Chute improvement – extended for less impact
- Relocation of ultrasonic seal to Position 2 – deferred
- Parallel alignment tool – developed and tested working
- Limited quantity production – conducted as IPR II Part 2

3. The July 30, 2003 test production initial results:
   - 9,000 pouches produced
   - Samples were pulled for inspection as per normal procedure. Heightened inspection was conducted as requested by USDA.
   - Product inspected 100%. Seal area was inspected more vigorously than by the normal procedure.

4. Observations and Conclusions:

   - General observation – Process was much better than in May. The team has learned a lot of things in the interim
   - Both USDA and Natick are generally satisfied with seal performance.
   - Based on the information to date, and unless unforeseen hurdles arise, USDA expects inspection of ultrasonic sealed pouches to be manageable. No obstacles has been identified to full process implementation.
   - Recommend increase sample size (500/lot or 315/lot - current is 200/lot) for seal evaluations and internal pressure; 32 samples to establish a quality history. Need to produce typical defect seals for references in inspection.
   - "Eruptions" (spots of damaged aluminum foil) shall be treated same as de-lamination.

   - Needed:
     - o Complete evaluations by Sopakco, USDA, Natick, and OSU/EWI.
     - o Sopakco submit lot to USDA
     - o Sopakco submit lot to DSCP - *Phase 3 will start after DSCP buys ultrasonic-sealed pouches*

7. Recommendations made:

   - Phase 3 extended production evaluations time to be set

- Relocation of ultrasonic seal to Location 2 for production speed has to be done prior to starting Phase 3
    - EWI/Chase M&E assistance to be requested in unit relocation.
    - May run another lot after relocation of sealing station.

- Sopakco to develop standard operation procedure
- Heightened level of inspection during Phase 3
    - Sample size: 500 samples/lot
    - Burst test: 32 samples
    - Minimum continuous seal width: ⅛ in.
- Technical assistance needed from EWI and OSU during Phase 3
    - Additional visits to be funded for EWI and Chase M&E assistance during the relocation

7. Action items

- Sopakco will send 72 random samples each to Natick, USDA, DSCP, and OSU/EWI.
- IPR II report to be submitted for JSG.
- Demo video, draft early November at R&DA.

7. Adjourn

4.4.3 Test Run Results and Conclusions

Samples gathered during the July 29-30, 2003 test run has been shipped from Sopakco for evaluation to Natick, USDA, DSCP, and OSU/EWI, and the evaluation has been completed. EWI peel test data is presented in Table 5.

The results of the test run evaluation were discussed during conference call on September 16, 2003, at which time IPR II was formally completed. The agenda, meetings notes, and comments are provided in Appendix A.

As a result of this conference call it was concluded that:

- *Both evaluations from Natick and EWI are completed. At this time, the evaluation results are favorable and conclusive.*
- *Based on the IPR II meetings, conference calls, and evaluation results, Phase 2 is successfully completed, and recommendation was made to initiate Phase 3.*

It was also concluded that with the attained plant confidence in seal quality produced by ultrasonic sealing, the option of replacing the heat seal with ultrasonic welder became available. This would allow using the quenching bar for additional cooling of the pouches and increase the speed of the packaging line, since Sopakco made a decision to relocate the ultrasonic seal and install it in the place of the heat seal unit. The decision was made to request EWI technical support and Chase M&E's assistance in unit relocation.

5.0 Phase 3

5.1 Moving Ultrasonic Welder to New Position

The initial steps of the ultrasonic welder relocation to a new position was carried out by Sopakco personnel prior to EWI and Chase M&E arrival. This included:

- Removing the heat sealer from the designated position
- Removing the ultrasonic sealer from the current position at the end of the packaging line
- Drilling new holes on the supporting rail and mounting and bolting the ultrasonic welder to the rail
- Relocating the pneumatic box with the manometers to a new position above the ultrasonic welder
- Disconnecting and reconnecting electrical and pneumatic connections once the welder was mounted.

As requested by Sopakco, a Chase M&E technician assisted in checking all of the electrical and pneumatic connections in accordance with the system integration diagram, and EWI has provided technical support in system tune up and testing. This part of the work was performed on June 8 and 9, 2004 and included the following steps:

- Aligning ultrasonic welder components and checking horizontal and vertical parallelism using the alignment tools developed by OSU
- Setting proper travel distance for the anvil
- Aligning pouch position at the welding station
- Aligning and adjusting pressure on cooling bars
- Adjusting the steam system to prevent pouch overheating
- Adjusting the packaging line speed to 36 pouch/min

- Process settings optimization
    - o Setting up energy (450 J), amplitude (95%), and pressure (65 psi)
- Initial test run and seal assessment

Initial seal quality testing has been performed on the production floor by Sopakco QC personnel. Pouches were tested by internal pressure and a “stylus test”. All collected samples have passed standard internal pressure test; however, the “stylus test” has showing some yielding areas on one side of the seal. Adjustments were made to the cooling bar alignment and after that the resulting quality improved – no yielding was observed on the seal.

As the utilization of the cooling bars has resulted in a different pattern on the pouch surface (the cooling bars pattern is superimposed over the ultrasonic welder pattern and partially obscures it), additional attention has been paid to visual characterization the seal area.

On May 26 and 27, Sopakco collected two batches of pouches (36 pouches of Cajun rice and 36 pouches of applesauce and raspberry puree) for further evaluation at EWI and OSU. Based on the sponsors’ request, the evaluation was focused on the seal area visual, microscopic inspection, and peel test.

The following evaluation results were presented to the project sponsors.

5.2 Samples Evaluation - May 26-27, Bennettsville Test Run with Cooling Bars

Pouches evaluated : 72
Products: Applesauce and raspberry puree - 36 pouches; Cajun rice - 36 pouches
Evaluation methods: visual inspection, microscope inspection of the seal area, peel test.
.

5.2.1 Visual and Microscopic Inspection

5.2.1.1 Product: Applesauce and Raspberry Puree

No unsealed areas or material damage were observed. On all of the inspected seals, the ultrasonic pattern is visible under microscopic inspection (if looking at the patterned side of the seal). On some of the pouches the pattern appearance is slightly uneven with more prominent ultrasonic pattern on the left side (if looking at the patterned side) of the seal. The ultrasonic pattern is slightly less noticeable on the right side, covered by superimposed cooling bars’ pattern. This might be a result of a slight misalignment of the cooling bars, which causes a higher pressure applied at the right side of the seal. However, *microscopic inspection of the* *seal area shows that the ultrasonic pattern, while not noticeable by visual inspection in some of the regions of the seal area, is still present under the superimposed cooling bars pattern* (Figure 16).

On one of the pouches it appears that the cooling bars were applied a little higher than ultrasonic seal (probably the pouch slid down during the transfer), leaving a small strip, about 2 mm of the original ultrasonic pattern. While noticeable with the naked eye as a two different patterns, under the microscope this area (above the horizontal line) looks very similar to the area where cooling bars were applied (under the horizontal line), as the ultrasonic pattern is still visible at this area under the microscope (Figure 17).

5.2.1.2 Product: Cajun Rice

One pouch has an area with reduced seal width (approximately 0.27 in.) on the right side of the seal (Figure 18). A 1-in. strip cut from this area had a peel strength value of 11.8 lb/in. It appears that this pouch and Pouch 8 from the same lot were produced at the beginning of the run when the equipment was not warmed up. No unsealed areas or material damage was observed on other pouches. On all of the inspected seals the ultrasonic pattern is visible under microscopic inspection (Figure 19).

5.2.2 Peel Test Results

Ten pouches of each product were subjected to the peel test. Three 1-in.-wide strips containing the seal were cut from the pouch for the test, which made 30 specimens total tested for each product. Average peel strength of the pouches produced with cooling bars is *20.6 lb/in.* compared to *19.4 lb/in.* value recorded for the batch produced during the test run on July 29, 2003.

Test results are presented in Table 6.

EWI evaluation results were presented to the project sponsors and approved during the teleconference, which took place on July 14, 2004. Based on EWI, USDA, and Natick evaluation results, the conclusion was made that: "*that MRE pouches produced by the new configuration (ultrasonic seal + cooling bar) are acceptable. The team recommends proceeding with submitting the six lots produced to end item inspections in Sopakco and USDA".*

5.3 July 28-29 2004 Plant Visit - Warm Up Procedure and Contamination Experiments

Based on the sponsors' recommendations made during the July 14 conference call, EWI and OSU have conducted a plant visit on July 28 and 29, 2004. The purpose of the visit was to:

- Monitor the packaging line performance during the 3-month test run, which by that time has been initiated by Sopakco
- Conduct a number of experiments, including testing of the ultrasonic sealing process robustness to product contamination in industrial conditions
- Take measurements and sample collection during the warm up procedure.

5.3.1 Horizontal and Vertical Alignment of Ultrasonic Welder Components

As the initial step of the shop floor experimentation, a check of horizontal and vertical alignment between the horn and the anvil was performed by EWI using OSU-developed alignment tool kit.

To perform the horizontal alignment check, the settings of the ultrasonic unit were changed by switching the system to the "off-line" mode, at which no ultrasonic energy is delivered by the horn to the part, and the advance of the horn toward the anvil was made to perform at a lower pressure. Two pre-calibrated load cells of the horizontal alignment tool were placed on the face of the horn and taped at the right and left ends of the horn as shown on Figure 20. The readings of the load cell reader were noted, and the anvil horizontal alignment was adjusted until the pressure readings from both cells were close (Figure 21).

Once the horizontal alignment check was complete, a check for the vertical alignment was performed. Vertical alignment was checked with the OSU-developed vertical alignment tool, which consisted of an assembly of custom-made base with two mounting brackets, fitted with a pair of laser sources, and a pair of triangular prisms. During the alignment check, the left beam was a reference beam where the reflector was mounted on the same base as the laser source, which was supported by the horn. The right beam was reflected by a prism that was supported by the anvil. The difference in distance (3 cm) between the two laser spots projected on the shop ceiling was used to calculate the deviation from vertical parallelism (amount of angular displacement between the horn and anvil), which was found to be less than 0.5 degree. The amount of angular displacement between the horn and anvil was calculated by:

$$A = \frac{1}{2} \tan^{-1} d/D \qquad (1)$$

where:

A = angular displacement between the horn and the anvil
d = vertical difference between the two laser marks
D = the distance between the point of reflection and the ceiling.

The team was satisfied with the vertical alignment check and it was concluded that no adjustment in vertical alignment was needed at this point.

5.3.2 Experiments with Product Contaminants

The purpose of this phase of the shop floor experiments was to evaluate ultrasonic process robustness to the most common food product contamination of the seal area. In order to do that, MRE pouches on the packaging line were manually contaminated with a Q-tip swabbing the seal area with selected contaminants after the filling station and prior to the steam injection point. Five types of food product contaminants, identified by the plant and most commonly presented in the industry were used in the experiment. These were water, sugar solution, apple sauce, oil, and food gravy. The pouches were contaminated and sealed with the product inside and 15 samples of each product were marked and collected from the Bartelt. These samples were then retorted in Sopakco in a retort chamber and subjected the pouches to 250^{o}F for 15 min. Three samples of each type of contaminant were tested in Sopakco for internal pressure and all 100% of tested seals passed the test. Internal pressure test results are presented in Table 7. The rest of collected samples were shipped to EWI for peel test. The peel test results are presented in Table 8.

Contamination test results were reviewed with the project sponsors during the conference call on July 29, 2004 and were reported on IPR III in Myrtle Beach, SC, on October 10, 2004. It was concluded that the results are positive and that "*This set of contamination tests confirmed that ultrasonic sealing with the cooling bar is tolerable to seal area contaminations".*

5.3.3 Measurements During the Startup Procedure

The purpose of this experiment was to verify and, if necessary, to optimize the operational practice followed in Sopacko. It was observed that after the production line was stopped for an extended amount of time, a number of pouches that were immediately sealed contained a lower than acceptable seal strength. This was attributed to the fact that that the travel distance set for the horn and anvil is based on the dimensions of the heated horn and anvil, as these components were getting heated from continuous welder operation. At the beginning of the process when the horn and anvil were cooler, the set gap between them was larger than optimum and; therefore, the anvil travel was not sufficient to close it, which results in lower bonding strength. To eliminate production of pouches with a weak seal, Sopakco was running about 60 empty pouches through the welder before its components would warm up and form an appropriate gap between them.

The experiment was designed to accurately determine the time before the horn and anvil will reach temperature equilibrium/warm-up time, and the number of empty pouches to be run through the welder before resuming standard sealing operation.

In order to determine the number of unacceptable pouches that are produced after a stoppage, the operation of the machine was halted to allow the horn and anvil to reach the environmental temperature. The line was started with speed of about 32 pouches per minute, running on empty pouches to eliminate the waste of the product. Anvil temperature was measured by an infrared temperature reader during the first 4 min of operation, at which time it was observed that the anvil temperature reached the equilibrium. The data was recorded and later plotted using Microsoft Excel software (Figure 23). As it is evident from the chart, the anvil temperature reached equilibrium in about 2 min, which was in the agreement with the current Sopakco start-up procedure, which prescribes to run 60 empty pouches prior to starting filling product. To verify these conclusions and further refine this start-up procedure, it was decided to collect the pouches during the start-up procedure and subject them to the peel test at EWI.

During the 2-min, 15-s time every other pouch was assigned a number and a sample size of 52 pouches was collected and shipped to EWI, where pouches were tested for their peel strength. The results of the peel strength test during the warm-up time of the ultrasonic welder are presented in Tables 9 and on Figure 24. The peel test results were in agreement with the observations made on the shop floor – the data show that it takes about 1.5 minutes (50 pouches) of welder operation for peel strength values to become consistent. The data was reviewed with the project team and discussed with the plant management. After the discussion the recommendation was made to follow current start-up procedure and run 60 empty pouches prior to starting filling product.

5.3.4 Test Line Speed

As one of the major operational objectives of Sopakco is to increase the packaging line production, it was important to establish the maximum possible line speed with the ultrasonic welder. In order to do that, the Bartelt line was tested at different speeds with the presence of Sopakco management and technical personnel.

Line Speed (p/min)	Performance	
	Ultrasonic welder	Line
32	OK	OK
40	OK	OK
44	OK	feeler vibrate
38	OK	OK, continued

As shown in the above table, previous line speed was set at 32 pouches per minute. The line speed was increased to 40 pouches per minute and operated for a few minutes normally. The line speed was further increased to 44 pouches per minute. While the sealing was normal, the operator observed vibration in the product feeler mechanism. The line speed was reduced to 38. This speed was set as the new line speed for future operation.

The theoretical line speed for the current ultrasonic sealing unit is 50 pouches per minute. This was calculated based on:

Ultrasonic Sealing Cycle Time (s)	
0.79	heating
0.1	holding
0.3	mechanical
1.19	Approximate index time
50.42017	Approximate max speed per min

This speed is currently limited by the mechanical performance of the Bartelt machine.

5.4 Technical Support Visit on September 9, 2004

This plant visit was requested by Sopakco to review packaging line performance and provide additional training to a newly assigned maintenance technician.

The visit took place on September 9, 2004, approximately at the middle of the 3-month test run. During the visit, the line performance and the inspection results of the lots submitted to USDA were discussed with the plant management. The seals of the pouches that failed the inspection were examined and the causes of defects were identified and discussed. The following observations were made based on the examination of the pouches with weak or incomplete seals:

- ***Defect - a leak pass at the end of the seal*.** The pouches that have a leak pass at the end of the seal were produced because they were not aligned perfectly with the sealer. The cause can be corrected by tightening the pouch transporting chain on the packaging machine.

- ***Defect - weak seal*.** It appears that the pouches with weak seal were produced during the drop in pneumatic pressure in the system. The cause was identified by the plant technical personnel and eliminated by bringing the pressure to recommended values.

- ***Defect – leak pass*.** Pouches have the entrapped matter that created a leak pass.

- ***Defect – weak seal on one side*.** One pouch with slightly uneven imprint that might be a results of uneven pressure application

Based on these observations the following recommendations were made regarding the line operation improvement:

- Tighten the pouch transporting chain on the packaging machine.

- Check alignment of the ultrasonic sealer components, and perform this check periodically, making the adjustments, if necessary.

- Constantly monitor the air pressure in the system on the manometer gage.

On the shop floor the line performance has been monitored during two ½-day shifts, September 9 afternoon and September 10 morning. During this time the consultations and on-floor training was provided to Sopakco technical personnel. This included:

- Technicians' involvement in horn and anvil alignment check and necessary adjustments using OSU-developed alignment check tools. The alignment check procedures were performed two times in order to provide additional practice to maintenance personnel.
- Training in start-up procedures.
- Discussing operational windows of welding parameters.
- Visual inspection of the seals.
- Discussing recommended maintenance procedures.

At the end of the visit, Sopakco management has expressed its full satisfaction with the visit results. During the IPR III in Myrtle Beach, SC, on October 10, 2004 the results of the 3-month test run were reported by Sopakco and USDA. The visit date was referred by Sopakco as a change in operations after which all 14 lots submitted to USDA passed on first submission.

6.0 Conclusions

The ultrasonic sealing technology was successfully implemented in production of MREs on the Bartelt packaging line. To attain this objective the following tasks were completed by the project team:

- The ultrasonic sealing process was optimized for quad-laminated materials in EWI's lab using a bench-top prototype system.
- The current packaging process on Bartelt packaging line at Sopakco Bennettsville facility was reviewed with the ultrasonic welding equipment vendor and system integrator, and specifications for integration of ultrasonic sealing unit in the packaging line were prepared and provided to the system integrator and equipment vendor.
- The integration module was designed, built, tested and shipped to the Sopakco Bennettsville facility.
- The module was successfully integrated in the line, tested, and tuned. The training was provided to the plant personnel.
- A series of short- and long-term tests and production floor experiments were successfully carried out.
- Technical support was provided to the plant during the ultrasonic welder relocation and the 3-month test run.

At this time Sopakco continues to operate the line with ultrasonic sealer and plans to do that in the near future. No problems with operation were reported.

Table 1. **Sealing Trials Data** (First run of the DOE.)

StdOrder	Run Order	Blocks	Energy (J)	Hold Time (s)	Surface	Peel Strength (lb) Left	Center	Right	Avg. Peel Strength (lb)	Weld Time (s)	Weld Dist (in.)	Peak Pike Power (W)	Abs. Dist. (in.)	Failure Location
1	1	1	600	0.3	No damage	20	23.2	20.2	21.13	1.443	0.0018	547	5.004	Parent material
2	2	1	600	0.3	No damage	19.2	20.4	19.4	19.67	1.44	0.0017	538	5.0038	Parent material
3	3	1	600	0.5	No damage	16.2	18.4	22	18.87	1.483	0.0018	530	5.0039	Parent material
4	4	1	600	0.5	No damage	17.4	19.4	18.2	18.33	1.695	0.002	527	5.004	Parent material
5	5	1	600	0.9	No damage	13.8	14.6	21	16.47	1.658	0.0019	525	5.0041	Parent material
6	6	1	600	0.9	No damage	18.4	20.8	17.6	18.93	1.619	0.0019	537	5.004	Parent material
7	7	1	700	0.3	No damage	19	18	18.2	18.40	1.836	0.002	534	5.0041	Parent material
8	8	1	700	0.3	No damage	16.2	21	19.6	18.93	1.836	0.002	536	5.0041	Parent material
9	9	1	700	0.5	No damage	20.2	17.8	18.8	18.93	1.857	0.002	546	5.0041	Parent material
10	10	1	700	0.5	No damage	18.4	20.6	16.4	18.47	1.405	0.0017	537	5.0038	Parent material
11	11	1	700	0.9	No damage	15.4	22.6	14.2	17.40	1.516	0.0018	534	5.0039	Parent material
12	12	1	700	0.9	No damage	18.8	22.6	19.8	20.40	1.51	0.0018	535	5.0039	Parent material
13	13	1	800	0.3	No damage	14	17.8	20	17.27	1.668	0.0019	527	5.004	Parent material
14	14	1	800	0.3	No damage	17	19.4	19.2	18.53	1.664	0.0019	528	5.004	Parent material
15	15	1	800	0.5	No damage	19.8	18.6	19.2	19.20	1.647	0.0019	530	5.004	Parent material
16	16	1	800	0.5	No damage	18.4	21	17.8	19.07	1.818	0.0019	534	5.0041	Parent material
17	17	1	800	0.9	No damage	20.2	18	18.8	19.00	1.817	0.002	536	5.0042	Parent material
18	18	1	800	0.9	No damage	18.2	18.4	20.00	18.87	1.868	0.002	542	5.0041	Parent material

Table 2. Sealing Trials Data (Second run of the DOE.)

StdOrder	RunOrder	Blocks	Energy (J)	Hold time (s)	Surface	Peel Strength (lb)			Avg Peel Strength (lb)	Weld time (s)	Weld Dist (in)	Pk Power (W)	Abs. Dist (in)	Failore location
						Left	Center	Right						
1	1	1	600	0.3	No damage	20	23.2	20.2	21.13	1.443	0.0018	547	5.004	Parent material
2	2	1	600	0.3	No damage	19.2	20.4	19.4	19.67	1.44	0.0017	538	5.0038	Parent material
3	3	1	600	0.5	No damage	16.2	18.4	22	18.87	1.483	0.0018	530	5.0039	Parent material
4	4	1	600	0.5	No damage	17.4	19.4	18.2	18.33	1.695	0.002	527	5.004	Parent material
5	5	1	600	0.9	No damage	13.8	14.6	21	16.47	1.658	0.0019	525	5.0041	Parent material
6	6	1	600	0.9	No damage	18.4	20.8	17.6	18.93	1.619	0.0019	537	5.004	Parent material
7	7	1	700	0.3	No damage	19	18	18.2	18.40	1.836	0.002	534	5.0041	Parent material
8	8	1	700	0.3	No damage	16.2	21	19.6	18.93	1.836	0.002	536	5.0041	Parent material
9	9	1	700	0.5	No damage	20.2	17.8	18.8	18.93	1.857	0.002	546	5.0041	Parent material
10	10	1	700	0.5	No damage	18.4	20.6	16.4	18.47	1.405	0.0017	537	5.0038	Parent material
11	11	1	700	0.9	No damage	15.4	22.6	14.2	17.40	1.516	0.0018	534	5.0039	Parent material
12	12	1	700	0.9	No damage	18.8	22.6	19.8	20.40	1.51	0.0018	535	5.0039	Parent material
13	13	1	800	0.3	No damage	14	17.8	20	17.27	1.668	0.0019	527	5.004	Parent material
14	14	1	800	0.3	No damage	17	19.4	19.2	18.53	1.664	0.0019	528	5.004	Parent material
15	15	1	800	0.5	No damage	19.8	18.6	19.2	19.20	1.647	0.0019	530	5.004	Parent material
16	16	1	800	0.5	No damage	18.4	21	17.8	19.07	1.818	0.0019	534	5.0041	Parent material
17	17	1	800	0.9	No damage	20.2	18	18.8	19.00	1.817	0.002	536	5.0042	Parent material
18	18	1	800	0.9	No damage	18.2	18.4	20.00	18.87	1.868	0.002	542	5.0041	Parent material

90% amplitude - sealing
Speed: 5 - peeling
L, C, R - facing textured side

Table 3. Peel Test Results for Retorted Pouches with Product

Sample No.	Settings		Peel Strength (lb)			Avg
	Energy (J)	Hold Time (s)	Left	Center	Right	
24	600	0.3	***15***	17.8	19.6	17.4666
25	600	0.3	16.8	18.2	19.2	18.0666
26	600	0.3	17	17.8	16.2	17.0
27	600	0.3	16.4	17.2	16.6	16.7333
43	600	0.3	16	18.4	13.6	16
48	600	0.3	15.2	15.8	17.4	16.13333
58	600	0.3	***9.8***	16.2	18.4	14.8
64	600	0.3	***13.8***	16.4	***17.6***	15.93333
35	600	0.3	18.8	14.8	17.2	16.93333
41	600	0.3	16.6	15.6	16.2	16.13333
47	600	0.3	16.4	13.6	15.4	15.13333
68	600	0.3	14.8	14	15.2	14.66667
110	700	0.3	14.4	15	14.2	14.53333
111	700	0.3	13.6	16.6	15.2	15.13333
122	700	0.3	14.8	12.6	15.6	14.33333
124	700	0.3	15.2	16.8	12.8	14.93333
139	700	0.3	16.4	15.6	14	15.33333
145	700	0.3	17.4	12	16	15.13333
162	700	0.3	16.8	19.4	12.8	16.33333
175	700	0.3	17.8	16.2	13.8	15.93333
190	700	0.3	17.8	16.8	14.8	16.46667
196	700	0.3	17	16.8	11.4	15.06667
204	700	0.3	13.2	18.2	15.2	15.53333
207	700	0.3	13.4	20	15.4	16.26667
216	700	0.3	15	17.4	15.2	15.86667
221	700	0.3	12.8	16.4	16.8	15.33333
5-Pechiney	700	0.3	15.4	19.4	17.8	17.53333
12-Pechiney	700	0.3	16.8	18.4	16.2	17.13333

Table 4. Peel Test Data for Samples Produced During the July 29, 2003 Short Test Run

Limited run lot 7/29/2003
10 random samples produced at 16:10 -16:13

Specimens L -left M -middle R-right

Pouch tested	L, lbs	M,lbs	R, lbs	Failure Location
1	20.2	20.8	23.4	parent material
2	18.2	16.8	24.4	parent material
3	17.4	18.4	18.4	parent material
4	16.8	21.4	24.2	parent material
5	18.8	20.8	21.8	parent material
6	19	18.8	18	parent material
7	18	19.6	21.8	parent material
8	17.8	20.6	19	parent material
9	15.4	18	18.4	parent material
10	18	16.2	22.4	parent material
	17.96	19.14	21.18	19.42666667

Table 5. Peel Test Results on Samples Produced with Cooling Bars, Collected by Sopakco on May 26-27, 2004

Pouches Produced with Cooling Bars				
PRODUCT: Apple sauce and Rasberry Puree				
pouch number		Peel Strength		
	L	M	R	
1	19.8	23	15.4	
2	19.6	22.2	20.8	
3	19.2	19.8	23.2	
4	20	24.2	24.4	
5	17	22.8	16	
6	19.8	19.4	22.2	
7	21.2	21.2	24.2	
8	19	15.6	17.6	
9	16.8	18	22	
10	20.6	21.6	17.8	
PRODUCT: Cajun rice				
1	20.8	22.6	23.6	
2	22.2	18.4	19.6	
3	19.4	19.8	23	
4	23.8	23.4	25.2	
5	N/A	23	24	
6	22.2	24.2	22.2	
7	18	19.6	21.4	
8	16.8	18.6	15	
9	20.2	23	21.6	
10	19.8	20.8	19.2	**Average total**
Average	**19.8**	**21.06**	**20.92**	**20.59333333**

Table 6. Results of the Internal Pressure Test Performed by Sopakco on Contaminated Seals

25psi for 30 seconds	
Contaminan	**Test Results**
Control	pass
Water	pass
Water	pass
Water	pass
Oil	pass
Oil	pass
Oil	pass
Red Sauce	pass
Red Sauce	pass
Red Sauce	pass
Apple sauce	pass
Apple sauce	pass
Apple sauce	pass

Notes: "Control" is normal sample, not intentionally contaminated. Water refers to tap water. Oil refers to vegetable oil. Red sauce was the sauce of noodle product. Applesauce was from a previously produced pouch.

Table 7. Peel Test Results of Contaminated Samples Produced by Sopakco on July 28, 2004

Pouch No.	Contaminant														
	Applesauce			Oil			Gravy Sauce			Water			Sugar Solution		
	L	M	R	L	M	R	L	M	R	L	M	R	L	M	R
1	16.8	15.6	20.8	15	16.9	18	15.6	16.2	17.4	15	15.4	18.348	15.2	16.4	16.8
2	15.8	15.4	19.6	17.6	16.2	22	20.8	17.2	13.6	15.2	15.4	18.897	15	9.8	16.8
3	17.4	12.8	15.2	18.6	15.4	19	15.6	14.4	16	20.6	15.6	19.358	15	13.4	14.8
4	17	16.4	22.8	16.8	18	18	11.4	11.6	19	15.8	11.8	15.736	17	15	18
5	14.2	12.6	20.8	16.8	15	20	17.6	18.4	17.2	18.6	12.4	19.115	15.4	18.2	18.2
6	18.4	12.6	20.2	17	14.8	20	14.2	15.2	20.2	14.8	11.8	16.694	16.2	11.8	14.8
Specimen Average	16.6	14.23	19.9	17	16.1	19	15.9	15.5	17.23	16.7	13.7	16.7	15.633	14.1	16.57
Contamin. Aver.		**16.79**			**17.4**			**16.2**			**16**			**15.373**	

Table 8. Peel Test Data for Samples Collected During Equipment Warm-Up Period on July 27, 2004

Pouch Number		Seal Strength (lb)	
	Left	Center	Right
1	9.2	8.4	13.6
2	11.6	9.6	12.2
3	11.4	11.6	13.4
4	9.4	12	13.6
5	9	10.2	14
6	12.8	11.6	11.8
7	8.4	13.8	11.8
8	10.4	13.6	13.4
9	13	9.4	12.4
10	9.8	14.6	12
11	13.2	12.6	12.6
12	11.6	14.2	13.6
13	12.4	12.4	10.8
14	12.2	10.6	10.8
15	12.4	12.2	11.8
16			
17	11.6	11.6	13
18	11.4	10.4	14.6
19	12.4	12.4	12.8
20	11.2	11.4	13.2
21	11.8	15.6	15
22	11.4	13.6	12.8
23	13.2	15.8	17.2
24	13.8	12.4	14.4
25	14.6	11.4	13.4
26	12.6	14.8	13.8
27	14	12.4	14.4
28	14.4	12	14.6
29	10.8	11.8	11.6
30	12.2	13.2	12.8
32	12.6	14.6	13
35	14.6	11.4	13.6
38	14.8	11.6	18
52	13.4	12.8	13.6

Time (In min)	Seal Strength (lb/inch)		
	Left	Center	Right
0.0625	9.2	8.4	13.6
0.125	11.6	9.6	12.2
0.1875	11.4	11.6	13.4
0.25	9.4	12	13.6
0.3125	9	10.2	14
0.375	12.8	11.6	11.8
0.4375	8.4	13.8	11.8
0.5	10.4	13.6	13.4
0.5625	13	9.4	12.4
0.625	9.8	14.6	12
0.6875	13.2	12.6	12.6
0.75	11.6	14.2	13.6
0.8125	12.4	12.4	10.8
0.875	12.2	10.6	10.8
0.9375	12.4	12.2	11.8
1			
1.0625	11.6	11.6	13
1.125	11.4	10.4	14.6
1.1875	12.4	12.4	12.8
1.25	11.2	11.4	13.2
1.3125	11.8	15.6	15
1.375	11.4	13.6	12.8
1.4375	13.2	15.8	17.2
1.5	13.8	12.4	14.4
1.5625	14.6	11.4	13.4
1.625	12.6	14.8	13.8
1.6875	14	12.4	14.4
1.75	14.4	12	14.6
1.8125	10.8	11.8	11.6
1.875	12.2	13.2	12.8
1.9375	12.6	14.6	13
2	14.6	11.4	13.6
2.0625	14.8	11.6	18
2.125	13.4	12.8	13.6

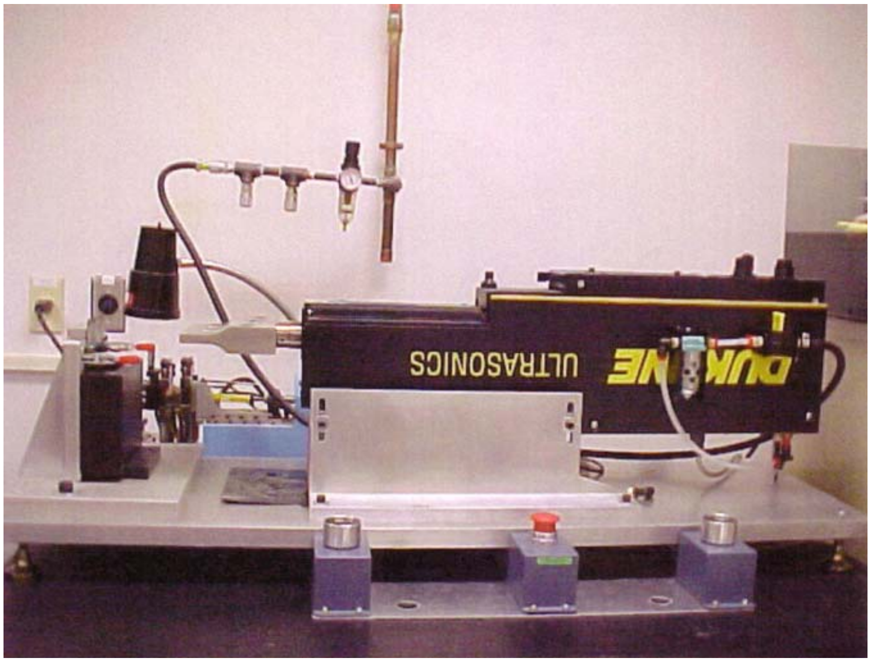

Figure 1. 20-kHz 2-kW Bench-Top Prototype Ultrasonic System for Sealing MRE Pouches

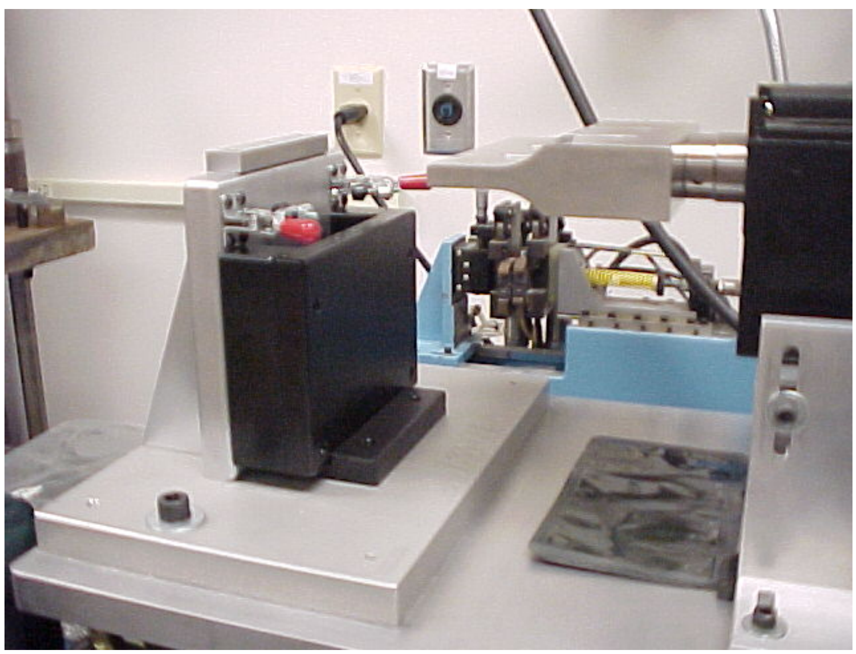

Figure 2. Pouch-Holding Assembly

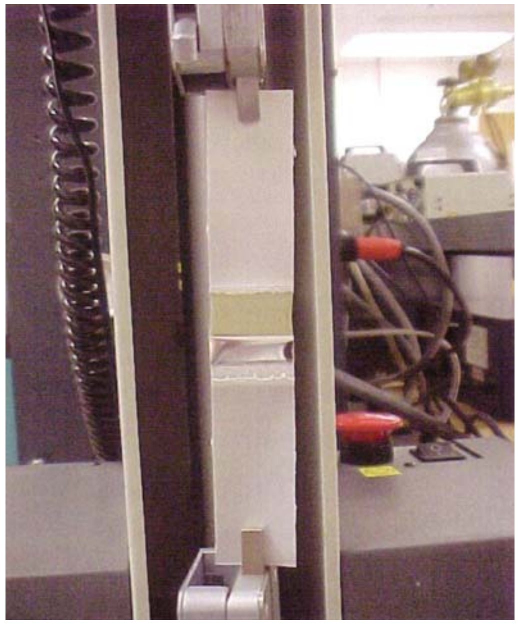

Figure 3. **During the Peel Test, All Successful Seals Failed through the Parent Material (Center)**

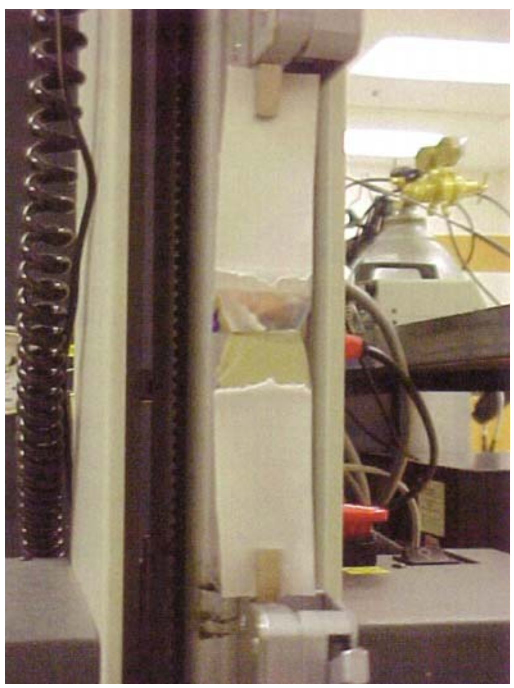

Figure 4. **During the Peel Test, All Successful Seals Failed through the Parent Material (Left)**

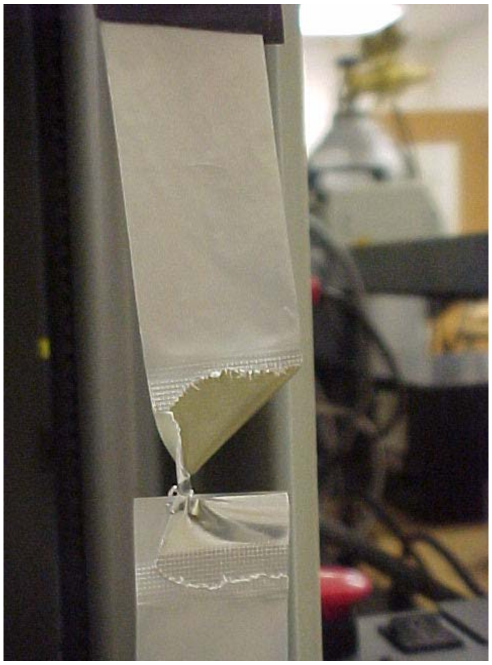

Figure 5. During the Peel Test, All Successful Seals Failed through the Parent Material (Right)

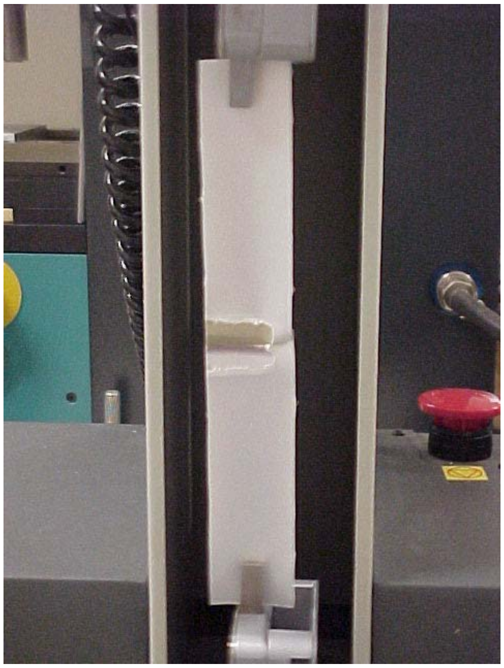

Figure 6. Example of Specimen Partially Failed through the Seal

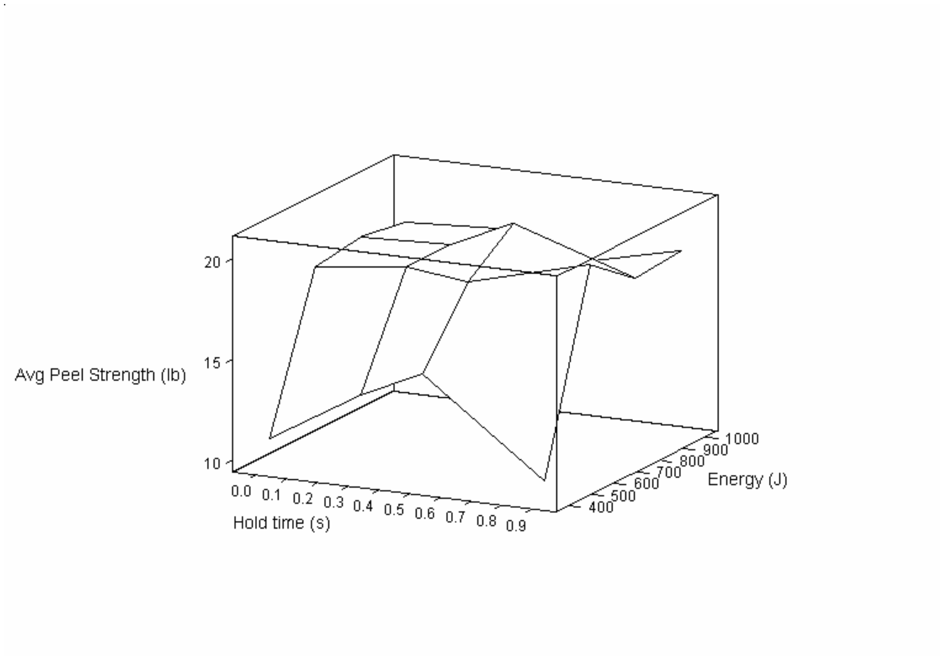

Figure 7. Peel Strength vs. Energy and Hold Time Surface Plot

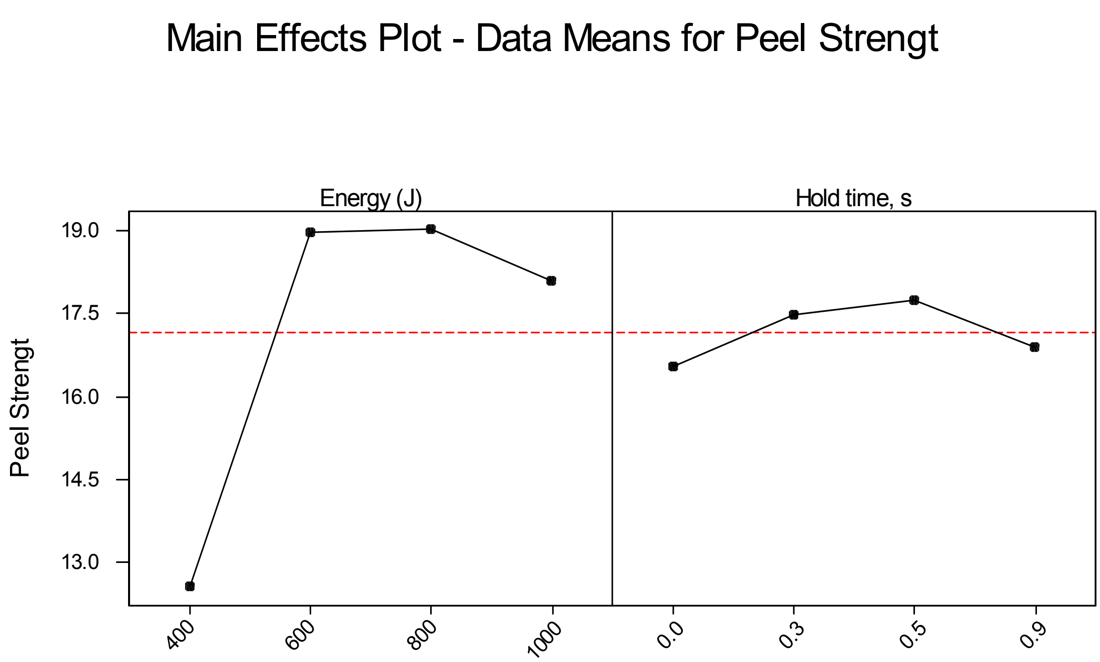

Figure 8. Main Effects Plot

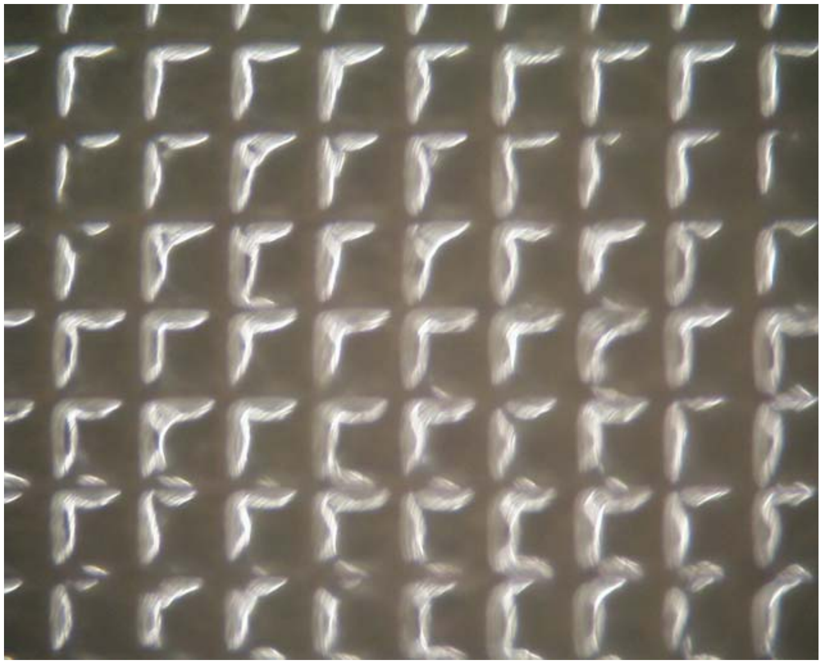

Figure 9. **No Material Damage in the Seal Area were Observed in Seals Produced in the Range of 600-800 J**

Figure 10. **Sealed Pouches with Product Ready for Retorting**

Figure 11. After the Pouches were Retorted at OSU, 10% of them were Brought Back to EWI, Cut Open, Emptied, Prepared to the Peel Test and Tested

Figure 12. Assembled Ultrasonic Sealing Module Ready for Testing at Chase M&E

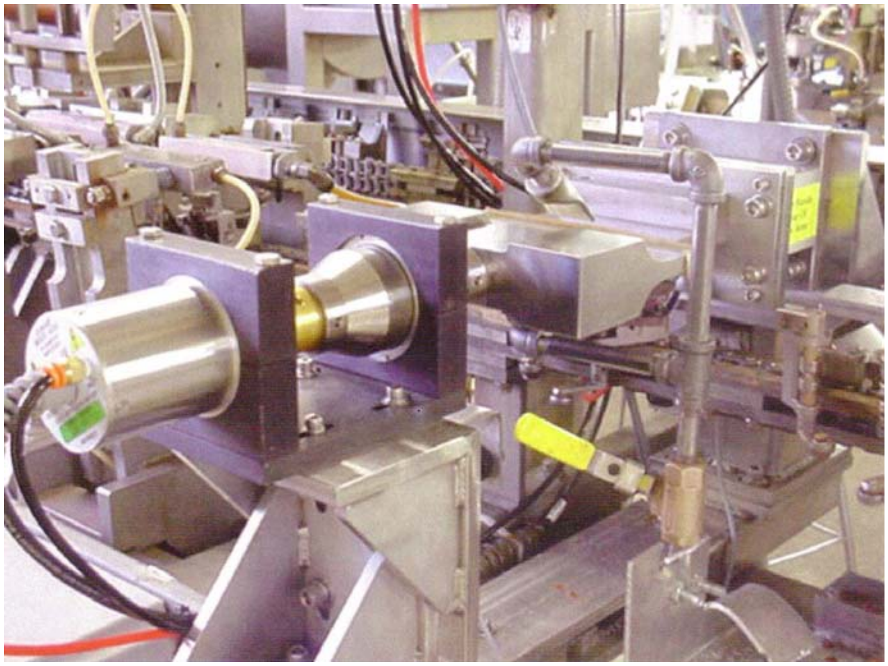

Figure 13. Ultrasonic Sealing Module Integrated in MRE Packaging Line

Figure 14. Sopakco Personnel Being Trained by Chase M&E Representative

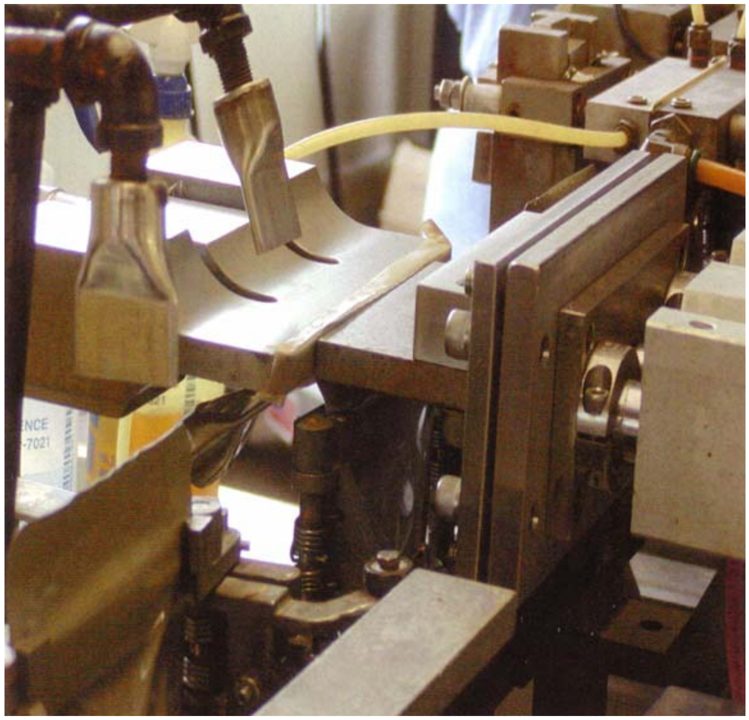

Figure 15. Additional Cooling for Horn and Anvil was Installed on the Sealer

Figure 16. Ultrasonic Welder Pattern is Visible under Microscopic Inspection

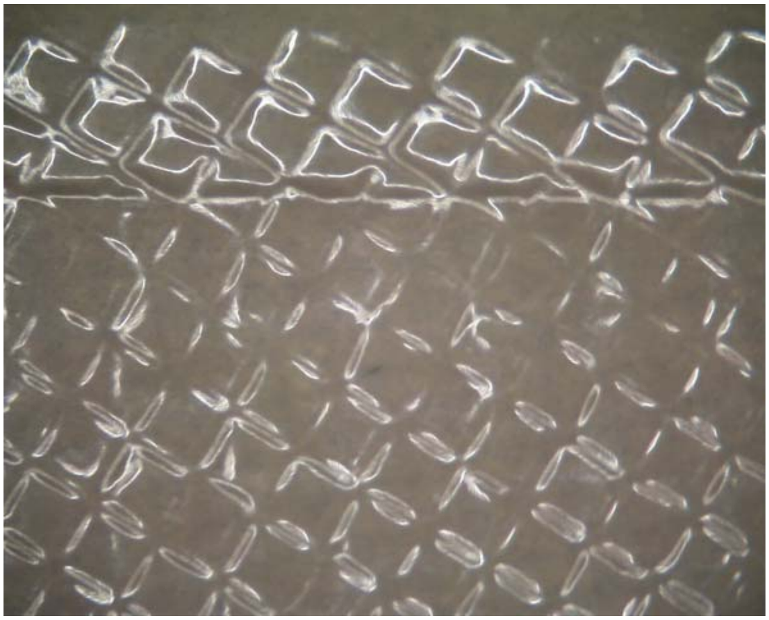

Figure 17. Cooling Bar Alignment Problem [Under the microscope the area below the horizontal line (where the cooling bars pattern was superimposed on the ultrasonic welder pattern) clearly shows the ultrasonic pattern and looks similar to the area without cooling bar imprint (above the line).]

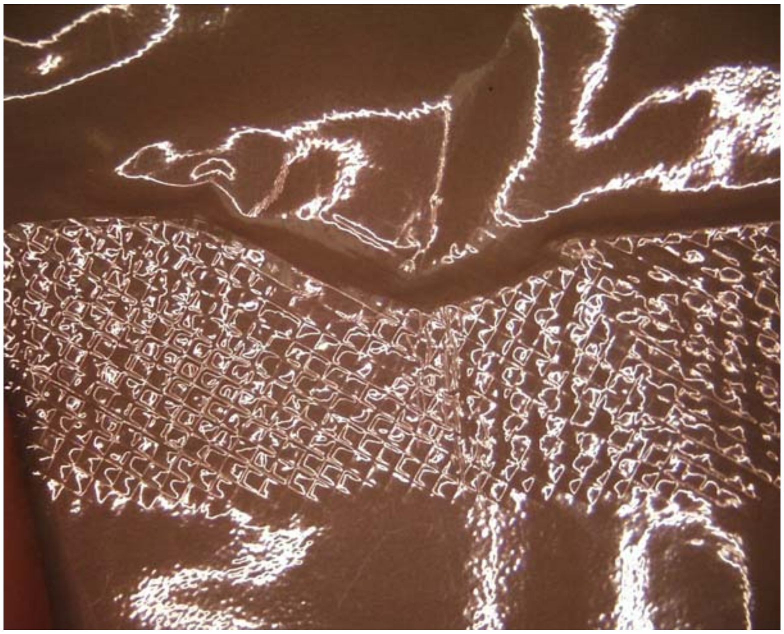

Figure 18. One Pouch has an Area with Reduced Seal Width (approximately 0.27 in.)

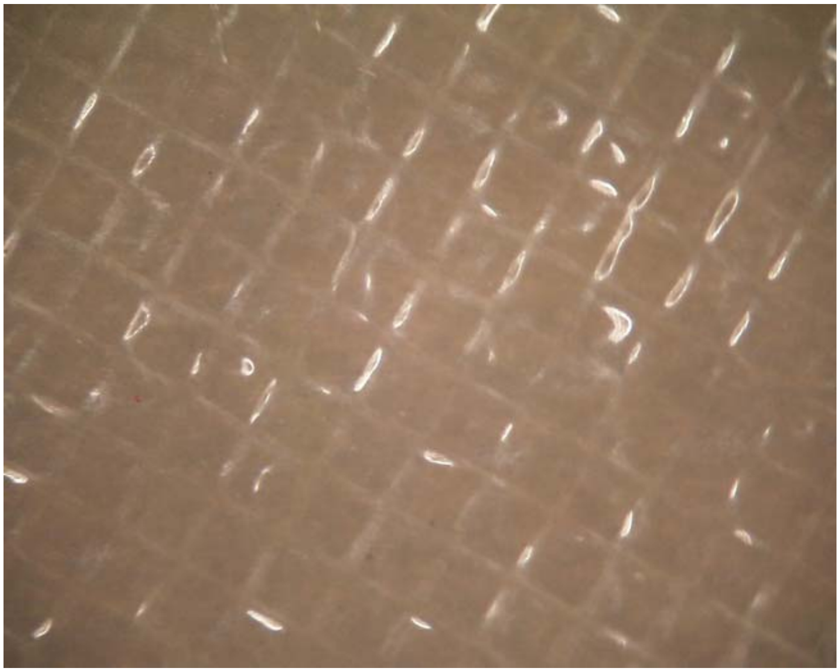

Figure 19. On All of the Inspected Seals, Ultrasonic Pattern is Visible Under Microscopic Inspection

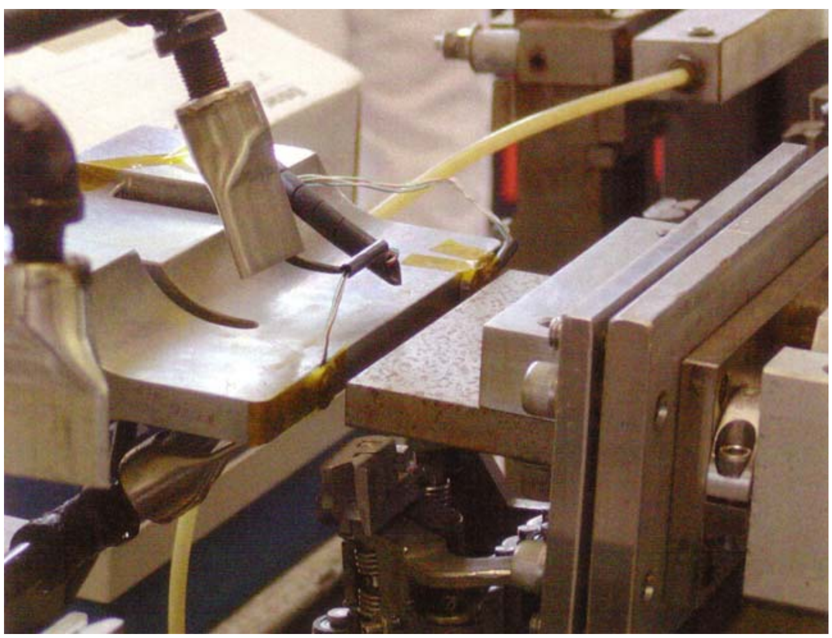

Figure 20. Two Load Cells were Mounted on the Face of the Horn to Perform Horizontal Alignment Check of the Unit

Figure 21. **Left and Right Ends Force Readings are Close to Each Other** (The two values indicate the amount of pressure each load cell experiences during the pressure application of the seal.)

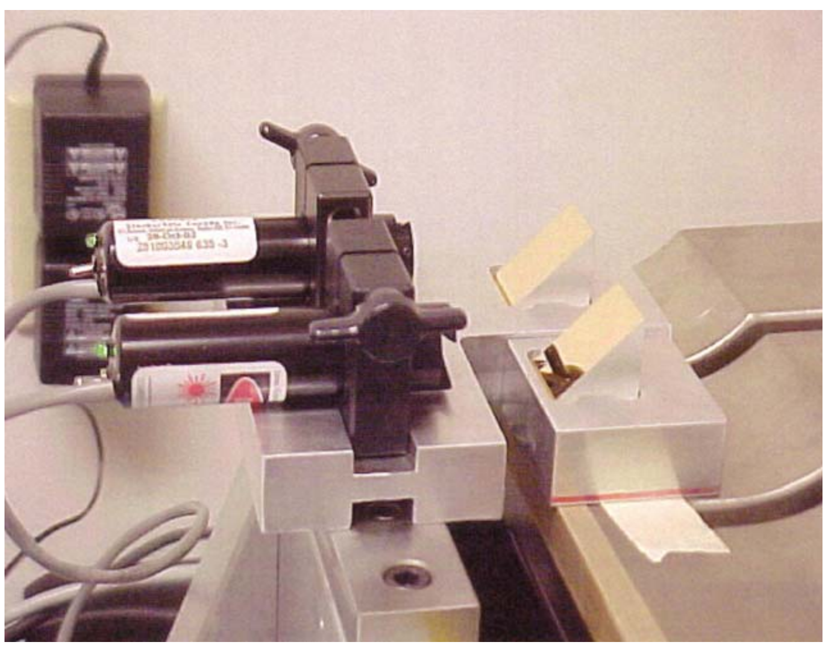

Figure 22. **Vertical Alignment Tool Developed by OSU Food Science and Technology Department**

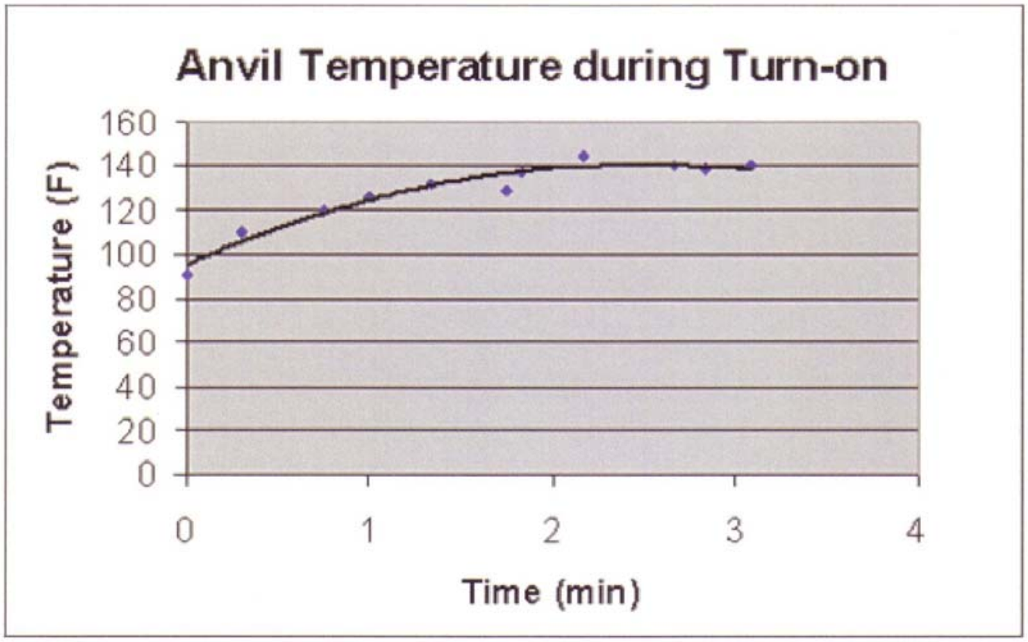

Figure 23. Anvil Temperature Data During the Welder Warm-Up

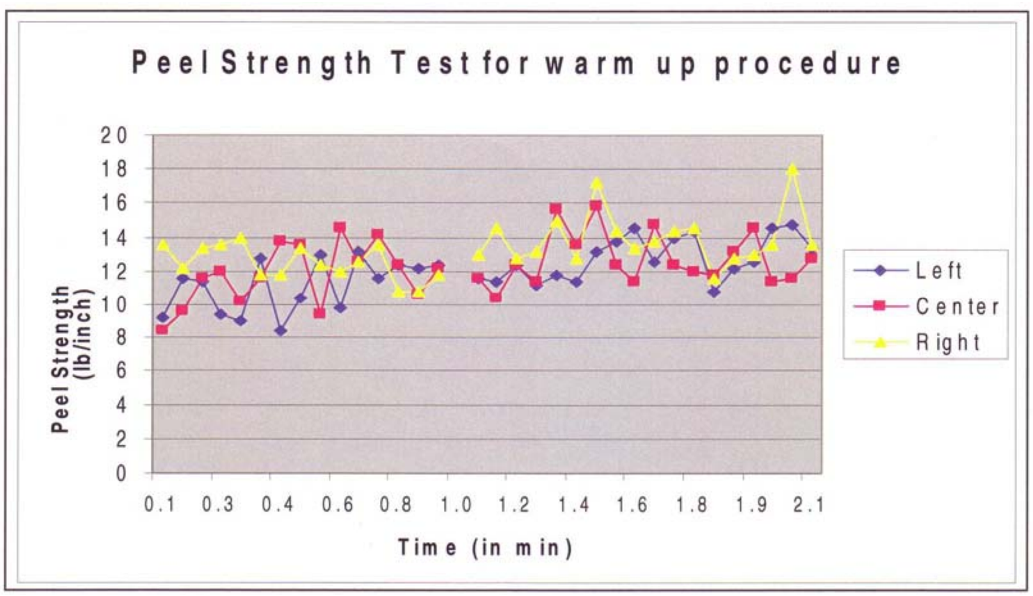

Figure 24. Peel Test Data for Samples Collected During the Equipment Warm-Up

Appendix A

Project Planning Minutes

STP 2004 Project Meeting - Minutes

July 23, 2002
Bennetsville
Sopakco Plant

Agenda

July 23

2:00-2:30	Meeting and introductions and agenda review
2:30-5:00	Packaging process review on Bartelt and other types of MRE machines Discussion of technical and economical feasibility of retrofitting different types of packaging lines with ultrasonic sealing components.

July 24

8:00-12.00 Discussion of plans to retrofit the Bartelt machine:
Development of specifications for the retrofitting:

- MRE manufacturer's requirements
- Identifying ultrasonic components
- Requirements for the system integration

Development of a working schedule

Participating:

JSG

Russell Eggers, DLA, Russell_eggers@hq.dla.mil, 703-767-1417
Peter Sherman, SBCCOM, peter.Sherman@natick.army.mil, 508-233-4062
Carol Norton, SBCCOM, carol.Norton@natick.army.mil, 508-233-5356

OSU/EWI

Howard Zhang, OSU, zhang.138@osu.edu, 614-688-3644
Alex Savitski, EWI, alex_savitski@ewi.org, 614-688-5235

Sopakco

Magdy Helfnaway, Unaka, Sopakco, magdyh@unaka.com, 423-639-1711
Lisa Prince, Sopakco, lprince@sopakco.com, 843-479-3811

Venders

Alan Baxter, Dukane, abaxter@dukane.com, 770-831-3133
James "Les" Kimley, Dukane, jkimley@dukane.com, 919-791-0340 or 0540
Julian Rokicki, Chase M&E, jrokicki@chasemachine.com, 401-821-8879

July 23, 2002

Team reviewed four types of MRE pouch machines:

1. Bartelt
2. 2× Rotary pouch machine
3. 1× Rotary pouch machine
4. Mitsubishi

All four types are technically feasible to be retrofitted for ultrasonic sealing. Approaches and cost estimates are summarized in the following table:

Type	Target Is (ppm)	Dukane (kW)	Integrator	Difficulty	Cost
Bartelt	40-44	2	Addition	Normal	1 nominal
2× Rotary	40	2 × 2	Replace	+1	2-2.5×
1× Rotary	32	2	Replace	+1	1-1.25×
Mitsubishi	40-44	2	Replace	+1	2-3×

Notes: ppm = pouches per minute
replace = replace heat seal station
nominal cost = retrofitting that of a Bartelt

July 24, 2002

Measurement of Bartelt:

- 16 in. between chains, outside room is not limiting
- Station nomenclature
    - Station 1 - Steam injection and preheating,
    - Station 2 - Heating
    - Station 3 - Cooling
    - Station 4 - Immediately after cooling station

Ultrasonic components (Dukane):

1. Generator, DPC IV or DPC III, 20 kHz, 2200 W. Mounted separate (up to 30 ft away)
2. Sealed Transducer (need one spare)
3. Booster (need one spare)
4. Ultrasonic horn, titanium (need one spare)
5. Cables up to 30 ft, firing, ultrasound, accessory

Delivery in 4-8 weeks to Chase M&E

Integration (Chase M&E):

1. Mount on existing two rails
2. Two modules, one sealing unit and one control unit
3. 0.5-in. travel anvil with angular alignment capability
4. Mounting location either Stations 2 or 4

Design and fabrication 8-10 weeks, install in 1 day shift. Need one maintenance person on site.

User specifications:

1. Wash down
2. Exposed parts non-corrosive
3. Easy operation – same as the heat sealer
4. Training for maintenance staff
5. Power requirement, AC line (208 or 480 VAC TBD)
6. Dry air pressure
7. Install either at Station 4 (after cooling station) or 2 (existing seal station)

Detailed user specification to be provided to EWI by Sopakco

Working schedule – attached MS Project file.

Action items:

1. Sopakco
   Supply 1000 blank pouches and 300 pouches with product to OSU
   Supply retort condition 35 psi, 250°F, holding time (Sopakco TBA) to OSU
   Supply user specification to EWI

2. EWI
   Request safety clarification information from Dukane, such as noise level and effect to operator, etc.
   Conduct optimization study

3. Venders
   Dukane – send quote to EWI
   Chase M&E – send quotes to EWI with breakdown of design, fabrication and installation

Adjourned 11:40 a.m.

IPR II Conclusion Conference Call Summary

Date: Tuesday, September 16
Time: 9:30-11:30 a.m.
Phone number to call: 614-292-6666, meeting id 5555

Participants: Howard Zhang (OSU), Alex Savitski (EWI), Peter Sherman (Natick), Tom Gordon (DSCP), Richard Boyd (USDA), Sue Bonanno (DSCP), Magdy Hefnawy (Sopakco), Dennis Stewart (Sopakco)
Regrets: Jesse Burns (DSCP)

Agenda, meetings notes and *comments*:

1. Completion of Phase II - installation, setup and optimization

The intent of this meeting was to complete IPR II and move into Phase 3 of STP2004, extended production evaluations.

A. Setup and Optimization – EWI

The installation and optimization process was briefly reviewed by EWI. The horizontal alignment was helpful in eliminating eruptions. Added cooling helped to reduce wrinkles to a near elimination. Quality of seal is very good. Additional vertical alignment of the anvil versus the horn may be necessary, at the beginning of Phase 3, to produce pouches with straight seal lines on both sides of the seal.

B. Sample evaluations - Natick, USDA, OSU, and EWI

Natick performed peel tests - all samples were in the acceptable range; internal pressure tests - no failures and no creep. Details of Natick tests are included in Appendix 2. Peter concluded from his tests that the project is ready to move into Phase 3.
EWI has performed peel test on randomly chosen 10 pouches produced between 16:10 and 16:13 on July 29 received from Sopakco. From every pouch three 1-in. wide specimens were cut: left, middle, and right, looking at patterned side of the seal. Results looked good. All 30 specimens tested have failed through parent material and no observed abnormalities in failure mode. The test data is included in Table 5.

C. Production issues – Sopakco

Magdy and Dennis commented on production three issues:
1) Mechanical alignment of chain and grabbers in the Bartelt were serviced. The seal line will be more parallel to the pouch edge in future production.
2) The target speed for ultrasonic sealing was 40 pouches per minute. While limited by the travel distance from the ultrasonic seal station to the release station, cooling of the pouches was the major limitation for line speed. Sopakco ran at 32 pouches per minute in all previous production runs.
3) With the seal quality from ultrasonic sealing and reduced production order, the option of installing the ultrasonic seal stating replacing the heat seal became available. Sopakco will prefer relocating the ultrasonic seal station two to three stations ahead in the line to provide additional travel time for cooling, or to use the quenching bar for additional cooling of the pouches.

D. Status of lot for end item – Sopakco

Dennis and Magdy reported the inspection and delivery status of the July 29 production.
1) This lot was first submitted to USDA for inspection with a intensive inspection guideline with 500 samples per lot and ⅛-in. minimum seal width. One of the 500 pouches was found to have a seal width less than 1/8-in. but more than 1/16-in., which is the current specification for heat sealed pouches. This lot was rejected. This pouch with less than ⅛-in. seal width, however, passed subsequent burst test.
2) Sopakco reworked 100% of this lot and found one pouch with a pin hole in a non-seal area. All seal width were more than ⅛ in.
3) This lot was re-submitted to USDA for inspection and passed all end item tests. The lot was offered to DSCP as high quality product.
E-mail from Richard Boyd (10/02/03) Update -- I have learned from the USDA/AMS inspectors at Sopakco Bennettsville that the lot has now passed the pouch integrity exam.
E-mail from Tom Gordon (10/02/03) On the teleconference call we discussed this issue. If the product produced by Sopakco passes USDA's inspection, I [DSCP] would accept it.

2. Initiation of Phase 3 - extended production evaluation

Consensus was reached to conclude Phase 2 and initiate Phase 3, pending peer test evaluations from EWI and Natick. Issues were discussed and action items were identified.
Both evaluations from Natick and EWI are completed. At this time, the evaluation results are available and conclusive. Based on the IPR II meetings, conference calls, and the evaluation results, Phase 2 is successfully completed, and recommendation is made to initiate Phase 3.

A. Sopakco issues

a - Retrofitting Cost
Sopakco would like to have Chase M&E to relocate the ultrasonic seal station. EWI has a cost estimate from Chase M&E and is included in EWI's additional cost for Phase 3, which was submitted to OSU. Sopakco will provide technical assistance to Chase M&E as prior installation.

c - USDA Sampling
Dennis commented that on the recommended ⅛-in. minimum seal width and 500 samples per lot too time consuming for the 3-month testing.
Richard and Peter commented on establishing a confidence prior to relax inspection to the next lover level. It normally takes 10 lots of the same products to trigger the relaxation. Number of samples may go down from 500/lot to 315/lot, then the regular 200/lot. The ⅛-in. minimum seal width is to keep during the 3-month test period until enough data is collected to justify the relaxation to 1/16-in. minimum seal width.
Dennis commented on the number of products to run. If all 30 items were to be tested, as part of Sopakco regular production schedule, each product will run 2 to 3 lots. None of which will establish a 10-lot history.
Howard suggested test 5 to 6 products with the ultrasonic sealing during Phase 3. Dennis would look into production schedule and determine the number of products to be evaluated.

B. Process monitor and evaluations – EWI

Alex commented on monitoring the performance of ultrasonic sealing during Phase 3. EWI requests for additional funding, once approved, will enable his 3 more trips to B'ville.

C. Inspections – USDA
Richard reaffirmed ⅛-in. minimum seal width.

D. Lot delivery and acceptance - Sopakco and DSCP
Dennis commented that lot delivery to DSCP will be handled the same way as heat-sealed products. Tom commented that as long as the products pass USDA inspection, DSCP will procure.

3. Action Items

A. Additional budget and time needed
OSU
EWI
Sopakco

a. OSU will generate a request for extension with additional fund. Due to the delays in installation of ultrasonic equipment and limitation of the installation location, at the time of ramped-up production, we will need three months of additional time. We will request that the project be extended to March 31, 2004. EWI and OSU will need additional fund to cover the extended period and Chase installation cost. The total OSU/EWI request is estimated $45,000. *A draft of request is included as Appendix 3.*
b. Sopakco will negotiate with DSCP on a solution to the potential $68,000 loss due to running ultrasonic sealing at 32/min.
c. Tom will discuss above two budgetary issues with Sue and Jesse and let Howard know if DSCP is ready for a request for extension with additional fund.
d. Sopakco will look into production schedule and identify best time for relocating the ultrasonic sealing unit and initiation of the 3-month production evaluation.

B. Fall R&DA meeting Coranet Project Case Report
Due to the absence of Jesse, it was not clear if STP2004 will be briefed at the Fall R&DA meeting. Howard was asked to communicate with Jesse.
After communication with Jesse and Pat Dunne, Howard learned that both the polymeric tray project led by Bob Trottier, and our STP2004 will be briefed at the R&DA Fall meeting. We will have 30 min time on Monday as Session III-B: Combat Operations Network Case Study. We will have the later 30 min. Howard will make the brief report and having all partners as panelists for comments. Please let Howard know if you will be attending R&DA in Biloxi, Mississippi, November 3-5, 2003.

Conclusive remarks:
Ultrasonic sealing has been developed, tested, and implemented in MRE production. Limited production lot is acceptable with significantly less defects. The potential benefit of zero seal defect is expected and to be validated by the 3-month production evaluation. The team efforts amongst all partners are excellent and key to successful implementation of combat ration technologies.

Appendix A.2.1
EWI Peel Test Results

Limited run lot 7/29/2003
10 random samples produced at 16:10 -16:13

Specimens L -left M -middle R-right

Pouch tested	L, lbs	M,lbs	R, lbs	Failure Location
1	20.2	20.8	23.4	parent material
2	18.2	16.8	24.4	parent material
3	17.4	18.4	18.4	parent material
4	16.8	21.4	24.2	parent material
5	18.8	20.8	21.8	parent material
6	19	18.8	18	parent material
7	18	19.6	21.8	parent material
8	17.8	20.6	19	parent material
9	15.4	18	18.4	parent material
10	18	16.2	22.4	parent material

Appendix A.2.2
Natick Tests

1. Seal strength

We received pouches from six subcodes spread throughout the day's production. So we selected to sample across a broader spectrum of the days production than sampling conducted by EWI. Under Subcode 161 we selected one pouch each from each of the following time-stamps 0905, 0909, 0924, 0928. For Subcode 171 the pouches stamped 0941, 1000, 1012, 1024 were selected and on throughout the run. We conducted seal strength tests on 24 pouches, four ½-in. strips from each ultrasonic seal from each pouch were tested. Our larger sample provided us with a greater range of results, individual tests results from 11.1-26.86 were noted (these values include the correction for reporting the required units, lb/in.). Mean scores among all groups were in the high teens to low twenties lb/in. In fact, the most consistent segment of samples tested came from the same point in production as EWI's sample. Nonetheless, all samples were in the acceptable range. This is good news for completing Phase 2.

2. Internal pressure

The IP test was conducted on 12 pouches (two pouches from each subcode). No failures, no creep. It was noted that some of the pouches do not exhibit a straight edge at the base of the seal (product edge of the seal). In some instances the knurl will be present as a straight border at the perceived base of the seal but the actual sealed area will not incorporate the perceived straight edge border as the beginning of the seal at the product/seal interface of the pouch. In other instances the seal edge is not straight and has the appearance of a wavy or meandering line. This was also noted on samples that were tested on the inclined slide test. This issue was also discussed at the last IPR. I wanted to mention it again to remind everyone that there could be a perception that seal creep occurred during and internal pressure testing. It would be better or best if this issue could be addressed by proper equipment alignment.

3. Inclined slide tests

These were conducted at ambient, 25 and -20°F. No failures or damage noted at ambient and 25°F. At -20°F, one pouch out of 24 exhibited the type of seal fracture noted in previous tests. This represents a marked improvement over the initial testing results where there was a greater rate of this observation. There were no failures (leakage) at any temperature.

4. Other observations

One pouch of the overall sample of pouches received, labeled subcode 164, 16:14 timestamp, exhibited delamination in one corner of the pouch at the trailing edge of the ultrasonic seal. The pouch was wrinkled in this corner and the seal was relatively short. It appears that the pouch may have fallen on this corner causing the resultant wrinkle/crinkle in the corner. The outer ply delamination was easily propagated and the outer ply peeled away across the ultrasonic seal and down the side heat seal and into the product portion of the pouch. Upon observation it is not conclusive as to what caused the delamination. It may have nothing to do with the ultrasonic seal. This raises the question as to whether the pouch suppliers will warrant their pouches against delamination after their pouches have been ultrasonically sealed? Howard, we probably should have had some input from the pouch industry on this issue previously, but if we haven't, I think it would be a good idea for Sopakco to discuss this with their suppliers if they haven't already done so.

STP 2004 July 14 Teleconference Meeting Summary

Date: July 14, 2004
Time: 2:00-3:30 p.m. EST
Phone: 614-292-6666
Meeting ID 5555

Participated: Jesse Burns, Peter Sherman, Alexander Savitski, Richard Boyd, Dennis Stewart Howard Zhang
Regrets: Thomas Gordon, Assunta Bonanno, Magdy Hefnawy;

1. Members of the team called in and discussed agenda items. Jesse suggested on additional agenda item:

    1. Are those products produced by Sopakco using the process of [ultrasonic sealing + cooling bar] acceptable? If so, are there any recommendations for the USDA inspection service?
    2. Evaluation of tolerance to seal area contamination is tentatively scheduled for July 27 and 28 in Sopakco. Alex, Howard, and one graduate student plan to be there.
    3. IPR and video for the October Coranet workshop

2. Comments and discussions

Review of evaluations of MRE pouches

Peter: Natick evaluation was e-mailed to the team early today. In general, pouches are all good. Natick is ready to talk about moving on. Suggest to go ahead to submit to USDA for inspection.

Alex: EWI evaluation was e-mailed to the team early today. All samples are acceptable. A couple of Cajun rice samples have narrow seal width but higher than ¼ in. and seal strength is still good. Imprint of ultrasonic seal is visible under microscope. Average seal strength of this new configuration [US Seal + Cooling bar] is higher than those of previous configuration [US Seal + air cool].

Richard: Overall seals are looking good. Evaluated 72 each. Cajun Rice samples allowed probing but kept enough seal width. One sample allowed probe through with fibrous seal area contamination. This sample should be caught as entrapment defect. Four pouches had hairline creases. When cut in cross section it appears as miniature delamination of the external layer. One instance of ⅛-in. yield but did not compromise the seal. Angled seal but seal is still fine. Applesauce samples, some with slight yield. There are 18 samples misaligned between ultrasonic seal and cooling. The integrity of seal is still good. Cross section shows molten material. Overall strength is good.

3. Disposition of the lots produced

Answer to the first question is yes*. The team agrees that MRE pouches produced by the new configuration [US Seal + Cooling bar] are acceptable. The team recommends to proceed to submit the 6 lots produced to end item inspections in Sopakco and USDA*. Sopakco will mail a limited number of samples from lots in between (2, 3, 4, 5) to USDA and OSU/EWI just to check for consistency.

No further recommendation is made to inspection. These products will follow the heightened inspection schedule as recommended previously by the team.

4. Schedule of the contamination test

Alex, Howard, and a graduate student are scheduled to travel to Bennetsville on July 26. Tests will be conducted on July 27 full day and 28 a.m.

5. Next conference call is scheduled for Wednesday, July 28 1:00-2:30. Howard will set up send notice.

6. IPR, Video, and Coranet Workshop

Jesse discussed IPR video and related issues.

At this time, its does not appear necessary for the team nor the Coranet partners to visit Sopakco. Individual visit may be arranged separately with Sopakco.

Details of the demonstration video will be discussed during the July 27 Sopakco test, when Howard, Alex, Magdy, and Dennis get together. The video should cover technical details of the installation and operation of the ultrasonic sealing equipment.

STP2004 IPR is scheduled to take place in Myrtle Beach in October, the morning of second day of the Coranet. STP2004 team members are required to participate, present progress and answer questions. All Coranet partners are invited.

7. Phase 3 production

Phase III production will be initiated after the July 28 conference call. However, Sopakco may decide to schedule production prior to that point if in-house and USDA inspections are favorable.

8. Initiating Phase 1 of the retrofitting Mitsi project.

Details of the Phase 1 Mitsi project will be discussed as part of the July 28 conference call. Howard will submit necessary cost information to Jesse and Sue prior to the teleconference.

In summary, the team is convinced that the new process configuration is better than the previous configuration. MRE pouches produced should be submitted for inspection. Once passing the inspections, they should be qualified for DSCP procurement.